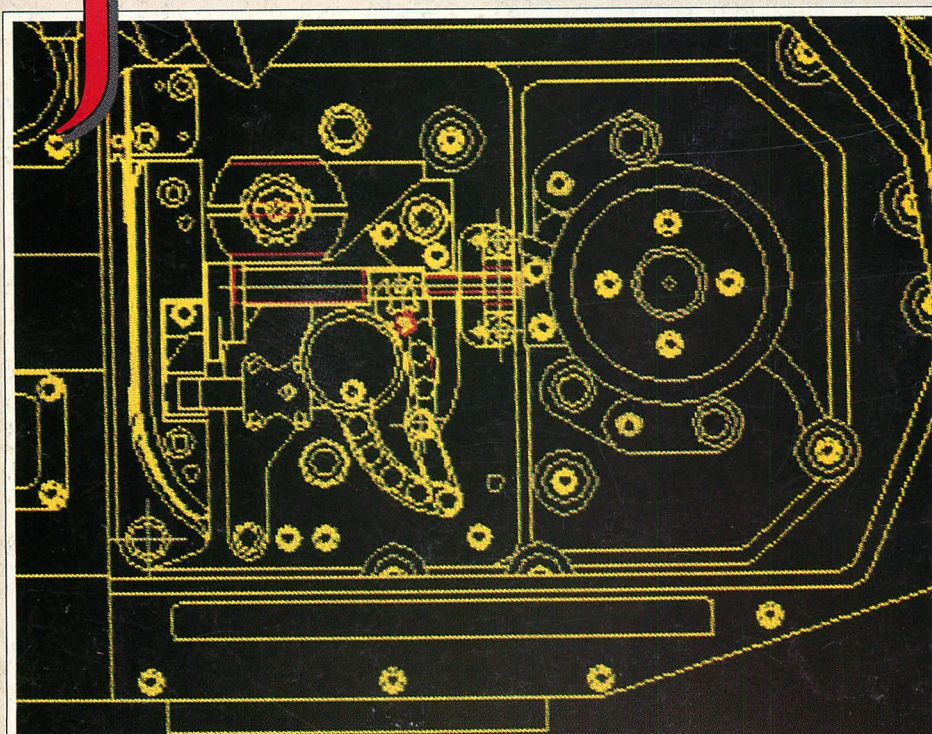


JANUARY 1986

VOL. 4, No. 1 \$3.95

FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL®



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Impressive Performance from AutoCAD

THE STATE OF C

DATA MANAGER REVIEW: Q-PRO4

3270-PC HIGH-LEVEL LANGUAGE API



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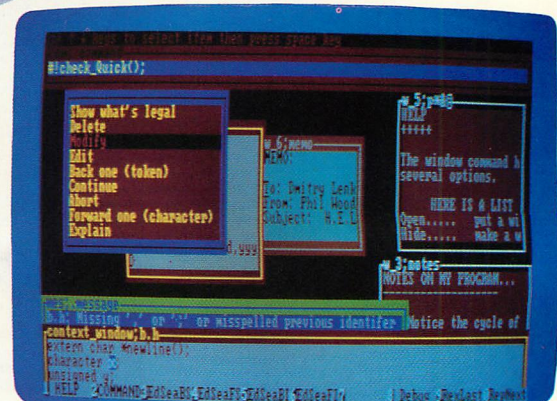
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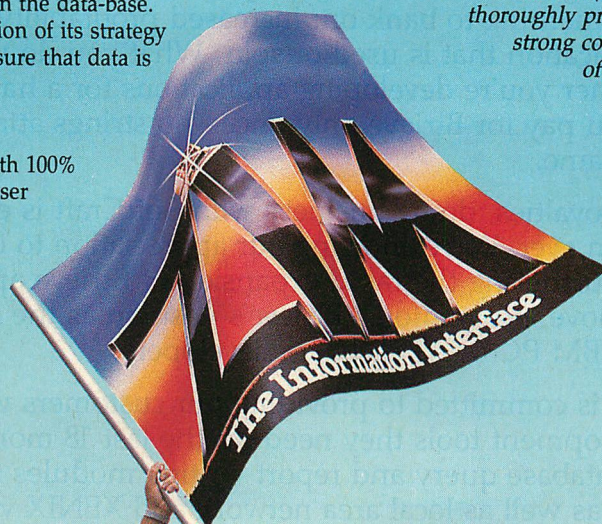
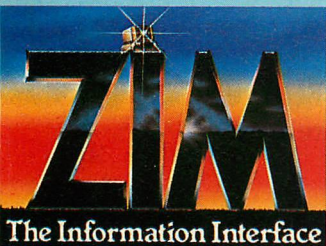
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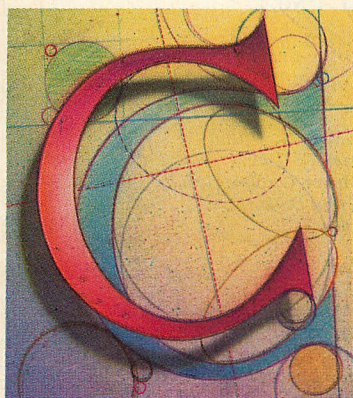


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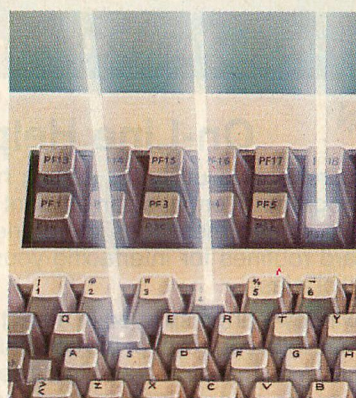
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AutoCAD 2.1 takes the concept of computer-aided drafting, adds a few design extensions, and delivers a product for microcomputers that approaches the proficiency of the larger CADD systems designed for mainframes and minicomputers.

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DRAWING TOWARD MONOCHROME / PETER AITKEN

Five graphics cards for monochrome monitors claim to provide the extensive graphics capabilities of color/graphics adapters. Cards from Everex, Genoa, Paradise, STB, and Tseng are evaluated. Four out of the five live up to expectations.

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THE STATE OF C / WILLIAM J. HUNT

An overview of a dozen C compilers examines the health of this programming language. The products tend to be uniformly good, indicating more programmers are using better compilers than ever before. The diagnosis: the state of C is excellent.

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KEYSTROKE AUTOMATION / JOHN SINGER

A micro-to-mainframe data transfer system is easy once all the pieces are in place: a 3270-PC, control program, and IBM's High Level Language Application Program Interface. These ingredients produce a link between the PC and a 3278/79 terminal.

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A DATA MANAGER FOR INTELLIGENT SCREEN FORMS / CHRIS CHRISTIAN

Business applications that require a highly controlled user interface with office forms are prime candidates for development with Q-PRO4. This data manager uses a forms processing approach, specially noted for its crisp screen performance.

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PROGRAMMING IN LOGIC / MICHAEL COVINGTON

Part 2 of this article examining the power of Prolog turns to the various implementations of the language. Eleven are reviewed—all of which show some rough edges. New versions are continually being released as Prolog's popularity increases.

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CURVES MADE SIMPLE / FRANK G. LETHER

A BASIC program is offered to users who want to plot data on the PC screen without becoming involved with the technical aspects of the PC's graphics commands. Many interesting and detailed curves are possible.

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—Peter Loats

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"I can't live without it!! BRIEF, a text editor my company wrote, would not be as stable as it is today without Periscope."

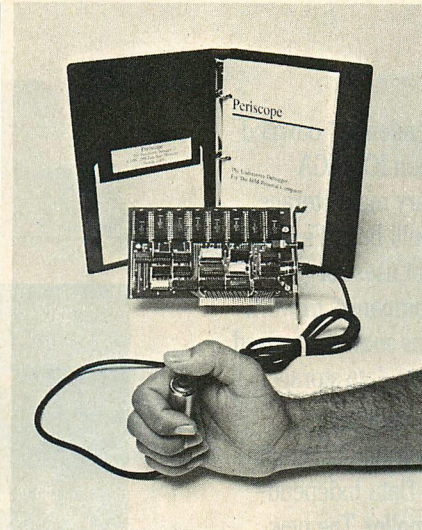
—David Nanian

With Periscope's broad range of capabilities, you can thoroughly debug your software, giving it the reliability it needs.

One user says that Periscope is a "superbly engineered product" with "virtually every feature possible!"

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- Optional On-line Help
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- Display memory in most any format



The break-out switch gives you what one user calls "spontaneity of debugging". Press it anytime to stop the executing program and see what's going on. The switch is so handy you'll want to use it to learn more about your PC!

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"Periscope has changed my programming life and is truly unique among PC debuggers. . . [it] enables me to debug keyboard routines, device drivers . . . without errors. Periscope is rock solid."

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Debug memory-resident and non-DOS programs, device-drivers, keyboard handlers, and interrupt-driven programs. Recover when your system hangs or your keyboard locks up. Safely check out what's going on in your system anytime. Debug when DOS is not working, debug DOS.

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GET THE BEST VALUE!

"[Periscope is] the best value in development tools currently on the market."

—Jeff Garbers

Time and again users tell us Periscope is underpriced. They tell us it pays for itself in a matter of hours after they begin using it. This means no professional software developer can afford NOT to try it!

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HOW TO DECIDE BETWEEN PERISCOPE I & PERISCOPE II

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The key difference between Periscope I and Periscope II is the 'Submarine' board included with the Periscope I package. When you install Periscope I, crucial debugger software loads into the board's memory, which is then write-protected. You don't have to worry about a runaway program destroying it! Periscope II loads into low memory.

BREAK-OUT SWITCH

The break-out switch included with either model of Periscope enables you to debug anytime, even if your system is hung. The Periscope II switch taps into an already-in-use slot, so you don't need a spare slot to install it. The Periscope I switch plugs into the back of the 'Submarine' board, which requires a slot.

WHICH MODEL DO YOU NEED?

If your program writes to memory below itself, you need Periscope I's protected memory to make sure crucial debugger software isn't overwritten. Other than the protected memory, Periscope I and Periscope II are functionally the same debugger!

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Atron's PC/AT Bugbusters

Hardware-assisted Software Debuggers for Bullet-proof PC/AT-based Products

A BUGBUSTER STORY

Brad Crain, a project manager at Software Publishing (the people who developed both PFS:WRITE and PFS:FILE), relates the following: "On Friday, March 22, 1985, I was about to get on an airplane with Jeff Tucker, who was co-author of PFS:WRITE with me, and fly to IBM's Boca Raton, Florida facility. For a week, we had been unsuccessfully trying to isolate a bug in a new software product. In a last, desperation move, I set up an early-Saturday morning appointment with ATRON.

"Three of us walked through ATRON's door at 8:00 the next morning. Using ATRON's hardware-assisted debugging tools, we had the problem identified and fixed by 10:30AM."

Mr. Crain concludes: "We'd never have found the bug with mere software debuggers, which have the bad habit of getting over-written by the very bugs they're trying to find. It doesn't surprise me that almost all the top-selling software packages were written by ATRON customers. Now that they've broadened their PC family of debuggers to include a PC/AT debugging tool, those of us seriously into 80286 development are greatly relieved."

ARE YOU TRYING TO DO SOMETHING SCAREY?

Like developing your AT-based software product in the dark? Without professional debugging tools?

Seven of the ten top-selling software packages listed by the *THE WALL STREET JOURNAL** were produced by ATRON customers. The PC PROBE™ bugbuster (\$1595) accounts for much of this success. Now that the PC/AT is the new standard for advanced commercial and scientific development, ATRON is proud to announce the AT PROBE™ bugbuster (\$2495). It has even more debugging capabilities than the PC Probe.

HOW BUGBUSTERS KEEP YOU FROM GETTING SLIMED

The AT PROBE is a circuit board that plugs into your PC/AT. It has an umbilical which plugs into your 80287 socket and monitors all processor activity.

Since AT PROBE can trace program execution in real time, and display the last 2048 memory cycles, you can easily answer the questions: "How did I get here?" and "What are the interrupts doing?"

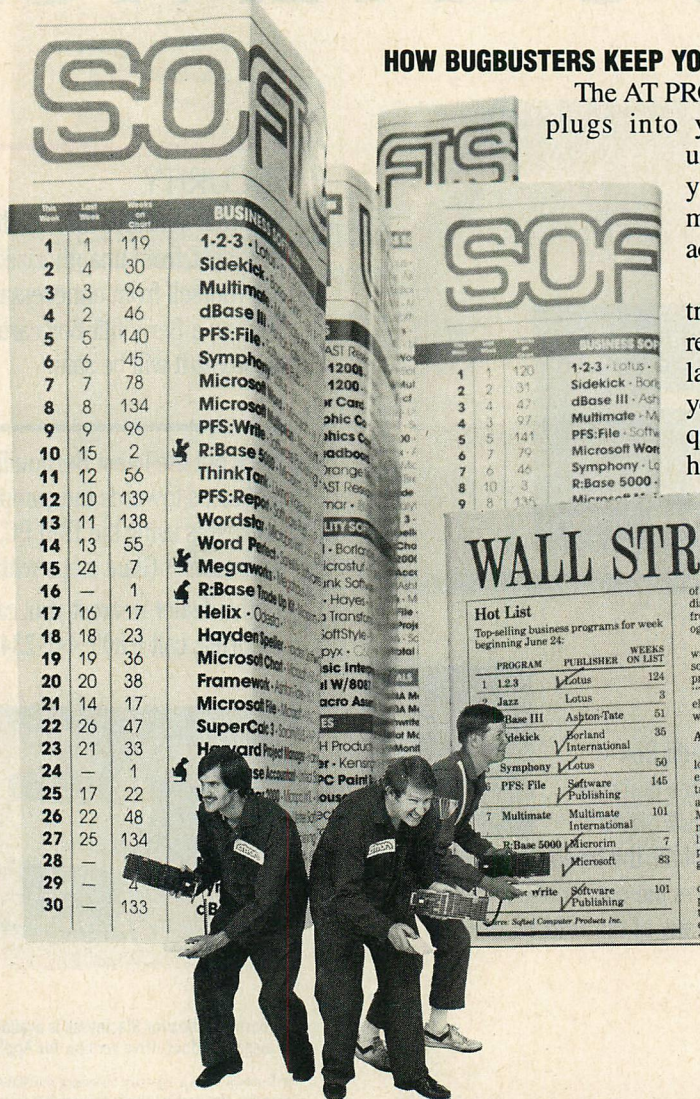
It can solve spooky debugging problems. Like finding where your program overwrites memory or I/O - impossible with software debuggers.

You can even do source-level debugging in your favorite language, like C, Pascal or assembler. And after your application is debugged, the AT PROBE's performance-measurement software can isolate your application's bottlenecks.

Finally, the AT PROBE has its own 1-MByte of memory. Hidden and write-protected. How else could you develop that really large program, where the symbol table would otherwise demand most of your PC/AT memory.

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CIRCLE NO. 203 ON READER SERVICE CARD

The LAN of IBM

The "Year of the LAN" may finally have arrived, but for some peculiar reasons.

Well, now they've gone and done it. IBM finally announced a product based on its token-ring research, and its first incarnation is, incredibly, for the PC. I say *incredibly* because the announcement has far-reaching implications for IBM, especially in light of the foundering PC-Network.

I thought the concept of a broadband network to be the correct one. Broadband technologies (RF and optical) offer a number of important advantages over baseband or twisted-pair systems, not the least of which is the enormous bandwidth that can be obtained. Today's RF broadband systems can operate 50 bidirectional channels at the same time, each running at 6 mHz (which can be translated into 6 mbs (megabits per second). Better yet, a single channel also can be used for video (a standard television signal), split into a number of high-fidelity audio channels, or digitized into thousands of voice channels. And therein lies the key to broadband: all this activity can be happening on a single piece of cable.

So I thought IBM was on the right path, even though broadband is difficult to install and maintain. Consider the advantages of attaching thousands of telephones and terminals to the same wire; the ease of switching the signal to microwave or satellite; the advantages of a system that can span a large geography (because the technology is the same as that used to deliver cable TV).

IBM's customers thought otherwise. Perhaps the investment in conventional cabling systems was too great to abandon, or the cost of installing broadband in an existing facility was too high. Given that some customers bought the recently announced IBM Cabling System and others lobbied for twisted-pair, IBM just had to capitulate.

That leaves PC-Network, just over a year old when the token ring was announced in October, with both feet in the grave. PC-Network's installation can

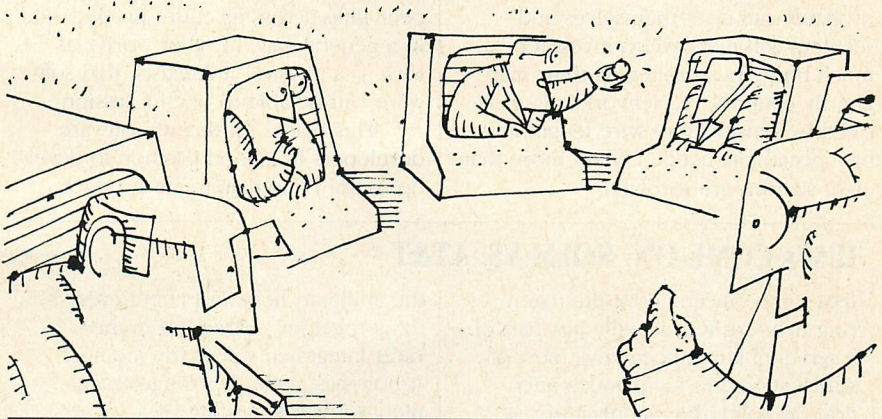


ILLUSTRATION • MACIEK ALBRECHT

be tricky, and its wire is so expensive that not many MIS departments, user departments, or small businesses are likely to select this approach. On the other hand, the token ring is easy to install and can use the cheapest wire.

In typical IBM fashion, PC-Network's death was *not* announced. Instead, the price went down and IBM's tone is that PC-Network is a very cost-effective product for the small office. I might have believed that, had they announced APPC (Advanced Program-to-Program Communications) support for it, but I am getting ahead of myself.

QUEST FOR THE TOKEN

The IBM Token-Ring Network already seems much more satisfactory than PC-Network to IBM's customer base. Response to the product has been strong, and most other LAN vendors have announced support for it, in effect creating a de facto standard before anything has even been delivered. Furthermore, the new LAN supports both the NET BIOS interface and the newer APPC interface, so software vendors who have been working on the PC-Network (or other networks that are NET BIOS compatible) can port their programs immediately. That relieves IBM of the embarrassment of explaining why no software is available.

Having NET BIOS for the token ring creates one small problem: the PC-Network board and the token-ring board cannot live in the same DOS-based PC, so the construction of a token ring to PC-Network gateway is complicated. IBM announced such a product, but the gateway requires its own PC and a hard disk, considerably raising the price. (Novell's software allows a PC to participate in both nets.)

IBM's customer base was a little miffed on one point. The cabling system IBM announced during the year can be used with the token ring, but for smaller installations (up to 72 PCs, says IBM), telephone wiring can be used. Some of those buyers of the cabling system think IBM sold them a bill of goods, first offering an expensive solution and then announcing support for a less costly option.

The market in general, however, seems much happier with this LAN approach than the previous one. It is faster than PC-Network (4 mbs versus 2 mbs) and probably will have significantly better throughput, the more important measure in any case. Wiring can be less expensive. The token-ring hardware is built so that components cannot be connected incorrectly, an important user feature especially appreciated by small businesses with no MIS support.

Another important factor is the automatic configuration capability of a token-passing scheme, a process that allows a node's physical connection to be made or broken at any time with no effect on the network's operation.

IBM designed the network hardware with simplicity in mind. Each PC node requires an interface board, a cable, and a place to plug the cable. When the places to plug the cable (call these, oh, say, *outlets*) are exhausted, another box of outlets can be added with no trouble. This is an idiot-proof installation, which means that users probably can do it themselves and retailers will not have to invest too much time, thus protecting their margin. By contrast, PC-NetWare is complicated by sensitivity to wire length and the special kits needed when more than eight stations are involved.

For the long term, however, it is the network software that is all-important to IBM. Logical Unit 6.2 (LU 6.2), or APPC, is the tie that binds. Everyone expects IBM soon to announce 6.2 support for the 3274 (an important mid-life kicker for 3270 technology and IBM's ability to make use of all those PCs pretending to be terminals). The token ring is the second instance of the protocol. We can assume (and IBM as much as said so) that connectivity via LU 6.2 and APPC will follow in System 3x, Series/1, and even the big guys. That means that IBM can establish peer-to-peer links across its entire product line in a general way. In other words, as long as a physical link exists, IBM software will be able to open a session.

This places third-party software developers in a good position to develop useful PC-to-mainframe products,

because the tough part of managing sessions and moving the data around will be transparent. Another annoyance, that of dealing with ASCII devices in the IBM world, also will be mitigated.

Better yet, 3270 technology will propagate throughout the network without (get this) the need for real 3270-style terminals or traditional 3270 wiring. In effect, IBM has made the 3270 completely soft. IBM probably would much rather sell the expensive (and well-margined) 3270-PC or -AT than any 3278 model. MIS departments are getting the idea, too: except for pure data entry, they would rather plunk a general-purpose device on someone's desk instead of a semi-dumb terminal.

The jury on IBM's token ring is still out. However, judging from the hubbub created so far, IBM appears to have struck a nerve.



IBM's COME-ON: ROLM VS. AT&T

IBM's announcement of the token-ring network was actually just part of a series of announcements, most of which served to focus much attention on Rolm, the manufacturer of telephone systems (primarily switches) that IBM bought last year. That acquisition was widely believed to be an admission from IBM that its own R&D had not panned out and that Rolm had viable technical and marketing strategies. The purchase also was viewed as a declaration of war against AT&T.

If that was the declaration, the recent announcements were the opening salvo. Two important facts emerged. First, IBM is showing off

the ability to hook just about everything together—albeit not in the most integrated way at the moment. It now has made its strongest statement to date regarding LU 6.2 and APPC, which is embodied in the new network and is promised for both the new 3274 and future token-ring announcements. IBM soon will have us marching to the LU 6.2 tune; can SNA be far behind?

Second, IBM is finally admitting that AT&T might be on to something. The token ring works on not only the IBM cabling system, but also telephone wire—just regular, old twisted pair. Golly. If IBM took this long to figure out everything, we

could be here until Halley's arrives the next time. Silliness aside, this is significant because so many people already have telephone wire and because future connectivity through a switch, preferably Rolm, will require this capability *in advance*.

IBM now must clarify this perceived ability to run the wire through the switch. Customers will want to use the same switch for voice and data, so IBM is placing tiny Rolm out on the giant AT&T gameboard. Whether IBM and Rolm can piece this together is anybody's guess, but one point is clear: once IBM has a reasonable product, it is a formidable competitor.

—WF

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We love to hear from you, but there seems to be growing confusion about where we are. Here's how to find the services you need from *PC Tech Journal*. By the way, this same information can be found every month in the masthead, which always appears on page 4.

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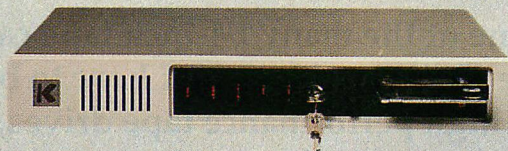
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If you *don't* have data worth preserving, then the reasons for buying Cartrex's new 1/4-inch, high performance, virtually error-free tape cartridge won't mean anything

But, if you are one of the many 1/4-inch tape cartridge users that assume 3M's cartridges just *have* to be "good enough" for today's high performance tape drives, read these simple facts to understand why that isn't true anymore.

PILOTS HAVE A SAYING,

"There are those who have made a wheels-up landing—and those who will."

You can apply this expression to those who have lost data and those who will. Unfortunately, data loss isn't always because users haven't backed-up their hard disk. Sometimes it's because their 1/4-inch tape cartridge, where they back up their hard disk, developed hard errors—those insidious errors that tend to increase over time. That's why Cartrex has developed a 1/4-inch data cartridge for today's high performance drives that virtually eliminates errors.

Why a new cartridge

When 3M announced its cartridge in 1971, it was designed for a low capacity tape drive with less than 3 megabytes—2.88 to be exact. The tape was low in density—1600 bits per inch with only 4 tracks and 300 feet of tape.

The tolerances required for the tape drives of the early 1970's were fine for then, but today's tape drives require much tighter tolerance. Today's tape cartridges must work with drives that have 9 or more tracks and bit densities as high as 12,000 bits per inch on 600 feet of tape. That means capacity increases of 2,000 percent packed into the same cartridge.

The reasons that yesterday's cartridge technology simply won't work properly in today's high capacity drives is inherent in the cartridge design.



The new Cartrex 1/4-inch tape cartridge is the first new tape cartridge design in almost a decade and a half. Tape drive manufacturers now have a new cartridge technology which allows them to advance beyond this previous artificial barrier.

With the significant increases in capacity, the three culprits that make cartridge tolerances so important are fluctuating tape tension, redeposit nodules, and instantaneous speed variations (or ISV).

Tape Tension

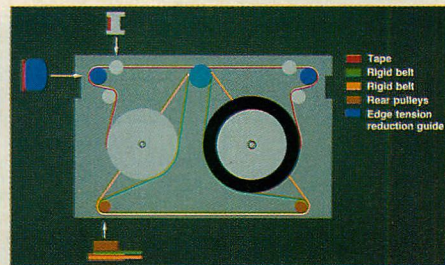
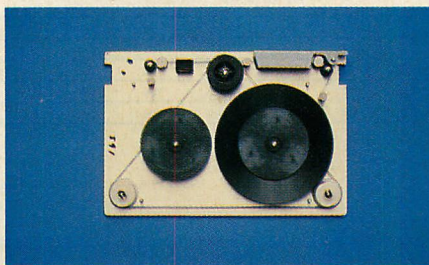
Any child who has played with a magnet understands that as the magnet is separated from metal, the magnet's ability to work is decreased. So

it's no surprise to find out that the closer the tape drive head is to the tape, the better the reading. This closeness is particularly important when the embedded iron filings get packed tighter in today's high density tape.

It's also important with the increase in the number of tracks. After

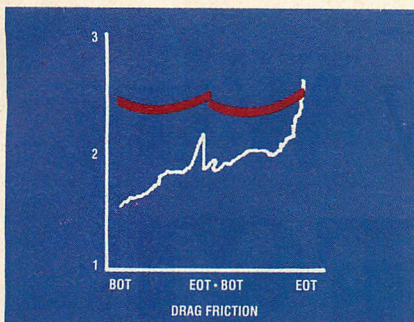
all, you wouldn't want the head to be reading an adjacent track any more than you'd want it reading more than one magnetic representation of a bit.

Unfortunately, tape tension historically has not been constant. As the tape unwound, the tension increased. What's important is both the *amount* and *range* of tension. A fluctuating increase or decrease in tension is as unacceptable as low tension is in the first place. As the accompanying graphs



The Cartrex cartridge design (upper left) uses the N2 principle which creates head-to-tape tension by applying a mechanical differential at the rear pulley between a stiff transport belt and a stiff tensioning belt, indicated in green and yellow in the color schematic (upper right).

The conventional 3M design applies drag at the rear pulley to create tension, which creates heat, and limits future speeds much above 90 inches per second.



Good head-to-tape tension ensures the highest probability of reliably capturing data. Fluctuating tape tension allows data loss due to head-to-tape separation and smearing redeposit nodules across the tape head. The Cartrex cartridge, compared to the conventional design, creates constant and higher tension.

show, the Cartrex cartridge has higher tension and flatter profile than the 3M cartridge. This means more reliable data across the entire tape.

Redeposit Nodules

Another reason to keep constant tension is to avoid "redeposit nodules" from smearing across your tape drive's head. What are redeposit nodules? They are the insidious flakes of tape media that break off from the edges of the tape and get dragged up to the edge of the tape head. If the tension is low, or becomes low when the tape starts or reverses, the flakes come up over the edge, get smeared over the head, and reduce its ability to read the data.

Even worse, however, is that these redeposit nodules are dragged along the surface of the tape and get embedded and packed over time. When your drive tries to read the data, the redeposit nodules act as a tent pole holding up the tape away from the head. As a result, even the best error-recognition algorithm can only tell you one thing—you've lost the data.

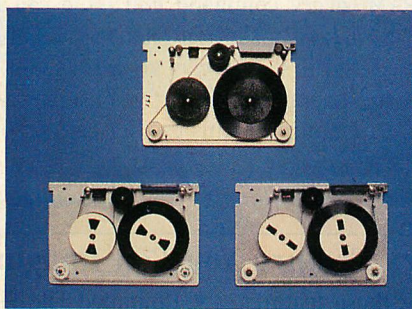
You might be wondering what causes the flaking in the first place. Again, it is cartridge design. The basic design uses a tape guide, shown in the accompanying illustration. The problem with this approach, is that it presupposes that the tape will always run parallel to the top and bottom caps of the tape guides. At the low speeds of

30 inches per second typical of when the 3M cartridge was designed, it was less of a problem. But at today's speeds of 90 inches per second and more, the tape wanders. When it presses against the top of the tape guide, the tape's edge pressure builds. Not only does media flake off, but you lose data due to the "coining" or "scalloping" effect.

Cartrex eliminated the cause of the tape coining or scalloping by developing a barrel-shaped roller placed prior to the tape guide. The laws of physics show that by riding on a rounded barrel, the tape will always seek the middle, reducing the tape edge pressure. This seemingly simple addition causes the tape to always enter the tape guide with zero edge pressure. In this way, the possibility of media flaking off and creating redeposit nodules is virtually eliminated.

Instantaneous Speed Variation (ISV)

Instantaneous speed variations is exactly what it sounds like—small, instantaneous changes in tape speed as it crosses the tape head. At slow tape



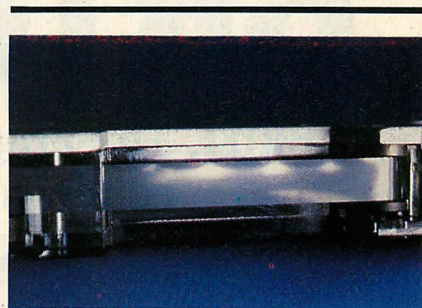
You can compare the Cartrex design on top with the conventional 3M design (lower left) and DEI, a 3M licensee (lower right). The omission of "edge tension reduction guides" (indicated in dark blue on the color schematic) on either the 3M or DEI design means that tape edge pressures will increase causing the magnetic media to flake off, smear across the tape head, and cause "redeposit nodules" to become embedded in the tape.

speeds and low bit densities—like the 1971 standard of 30 inches per second and 1,600 bits per inch—ISV wasn't as big a problem. At that time, the bits were crossing the head at 48,000 bits per second.

Today, however, the story has changed. 90 inches per second and 8,000 bits per inch mean that 720,000

bits cross the head every second. A 1,500% increase.

As you may have guessed, speed fluctuations in the 48,000 bits per second made reading data difficult for tape drive electronics. But when the electronics have to guess whether or not the bit rate of 720,000 bits per second is accurate, the electronics can become overwhelmed.



High speed tape without the "edge pressure reduction guide" seldom enters tape guides parallel to the top and bottom. The edge pressure which results creates "scalloping" or "coining" on the tape. The effect is data loss due to head-to-tape separation, flaking media that smears across the head, and "redeposit nodules" that create hard errors.

Never a Single Issue

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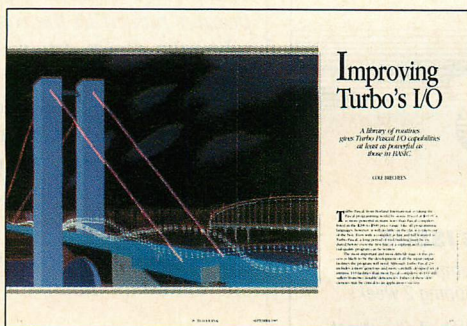
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MEMORY BLOCKS

In the September 1985 article "Improving Turbo's I/O" (p. 106), Cole Brecheen states that there is no mention of what *memory control blocks* are in the DOS 2.0 user's manual. Mr. Brecheen then speculates what a memory control block is. I'd like to point out that memory control blocks are described in detail in chapter 10, "DOS Memory Management," in the *DOS Technical Reference Manual* for version 2.1. I suspect that the typical DOS user has no need for that level of technical documentation and therefore IBM placed it in the technical reference.

Mr. Brecheen's article is a fine one; a little extra research would have made it better. All in all, I find *PC Tech Journal* to be an excellent source of information on the PC and would like to commend the staff and writers for an excellent publication.

Bruce L. Hillsberg
Sunnyvale, CA

For a complete discussion of memory control blocks we recommend that readers refer to "Managing Memory" (William J. Redmond, August 1984, p. 42) in addition to chapter 10 of the DOS 2.1 Technical Reference Manual.

—JA

CHARACTER REFERENCE

I recently had occasion to write a PC-DOS installable device driver to redirect output from LPT2 to an LA-100 serial printer, using XON/XOFF protocol. I was fortunate to find in Stan Mitchell's excellent article on device drivers in the May 1985 issue of *PC Tech Journal* ("Building Device Drivers," p. 76) just the reference I needed to obtain access to the command line in the CONFIG.SYS file. While writing my driver, however, I learned considerably more about command-line processing than appears in that article, and would like to pass this information on to others.

The article mentions that the presence of a parameter field is signalled by a line feed character <LF> without a preceding carriage return character <CR>. This is not strictly true. It seems that DOS, in its initial parse (during which the entire command line is converted to uppercase), makes the driver's path and file name into an ASCIIZ string by placing one byte of binary zeroes after the last character of the file name. If the file name is immediately followed by <CR><LF>, the zero byte does indeed replace the <CR>. On the other hand, if one or more blanks happen to be entered after the file name but before the <CR><LF>, the first blank will be replaced by the zero byte, leaving the <CR> intact.

It is thus unwise to assume that the absence of a <CR> on the command line indicates the presence of a parameter field. A better method is to search for any nonblank characters between the zero byte marking the end of the file name and the <LF>. If any are encountered, they are presumed to belong to the parameter field. I have tested this method by entering an arbitrary number of blanks after the file name, both with and without a parameter field, and have had no problems. I use a slash to mark my parameters, plus two characters for the parameter itself. In this way, I can make the command line self-documenting because anything after those two characters is ignored until either the next slash or the line terminator is found.

Something else I uncovered while writing my driver gave me a great deal of trouble, and I can find no reasonable explanation for it. Apparently, interrupt 10H, function 2, to access the BIOS video routine for setting the cursor position, causes the computer to hang. I could find nothing in the BIOS listing in the *Technical Reference* to account for this problem, and I can set the cursor position quite easily by writing

directly to the 6845 CRT controller chip, using exactly the same procedure that the BIOS does. If anyone has an explanation for this, I would certainly like to know what it is.

Robert D. Gould
Santiago, Chile

I understand Mr. Gould's objection to the use of a line feed character for determining the presence of a parameter field in the CONFIG.SYS command line. In brief, my reply is a direct quote from the article: "To determine whether a parameter field is present, scan the command-line string for the first carriage return or line feed. If a line feed is encountered first, no parameter field is present. If a carriage return is encountered first, a parameter field is present and the pointer points one character beyond the end of it."*

Mr. Gould's comments would be valid if in the last two sentences above, the phrases "line feed" and "carriage return" were interchanged. He does raise some good points about the insertion of 00H after the file name to make it an ASCIIZ string and about the conversion to uppercase characters.

When IBMBIO parses the CONFIG.SYS file, it makes two passes. The first pass tokenizes the file; the second pass executes the commands. Here is an example CONFIG.SYS file:

```
device = demodev.sys [this is a test string]
device = c:\util\ansi.sys
files = 10
buffers = 10
```

The tokenized version of this file under DOS 2.0/2.1 is as follows:

```
DDEMODEV.SYS<0>[THIS IS A TEST
STRING]<CR><LF>
```

```
DC:\UTIL\ANSI.SYS<0><LF>
```

```
F10<0><LF>
```

```
B10<0><LF>
```

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LETTERS

The carets indicate the position of the pointer passed in the request header when the device driver is initialized. Thus the entire contents of the CONFIG.SYS file are available at initialization time in the tokenized form.

It is interesting to compare the token equivalent that is generated under DOS 3.0/3.1:

```
DDEMODEV.SYS<0>[THIS IS A TEST  
STRING]<CR><LF>
```

```
DC:\UTIL\ANSI.SYS<0><LF>
```

```
F10<0><LF>
```

```
B10<0><LF>
```

The difference illustrated here is that a null <0> is not used to terminate the file name in DOS 3.0/3.1 if a parameter field follows the name. Thus, to be version independent, avoid using a null to help in positioning a pointer within a command line. As Mr. Gould recommends, it is best to use a unique delimiter (switch character) to indicate the string character of a parameter field.

It is no longer necessary with DOS 3.0/3.1 to make device drivers in .COM format disks before use. With DOS 3.0/3.1 the EXEC program loader is resident as a portion of DOS and thus is available when IBMBIO executes. Consequently, an .EXE file (without a stack segment) is acceptable as a device driver name in the CONFIG.SYS file.

Concerning the use of INT 10H for cursor positioning, I have not been able to reproduce the same symptoms with DOS 2.1/3.1. My suspicion is that it is a stack problem, but to give a definitive answer would require seeing the context in which the call is made. I had similar problems with using INT 10H functions from a console device driver that was used to pop up a window for entering logging information. My solution was to switch to my own local stack and prior to entering any INT 10H function, all registers were preserved and on return call registers were restored once the values in relevant registers were stored in memory.

—Stan Mitchell

PICTURE IMPERFECT

The quality of the articles in the November 1985 issue of PC Tech Journal was superb, as always. I have been reading this magazine for quite a long time now and always find the material to be intellectually stimulating. However, a technically unusual photograph on the cover of this issue prompted me to write this letter.

Flashy Programs.

TELEPHONE ORDER ENTRY FORM

Salesperson: _____ Ship To: _____
 Today's Date: _____ Zip: _____

Acct Num	Ship Date	Ship Via	FOB Point	Terms	Order Number

Quantity	Item Num	Description

Make Your Selection
 Add Record To File
 Edit Previous Record
 Go To Previous Record
 Press F1

ABC Computer Company
 New Client Information List

Company: _____ Billing Rate: \$ _____
 Contact: _____ Telephone: _____
 Title: _____
 Address: _____
 City: _____ State: _____ Zip: _____
 Referred By: _____ New Account(Y or N): _____ Auth Code: _____

ABC Computer Company
 New Client Information List

Account #: _____ Salesman: _____ Today's Date: _____

Company: _____ Billing Rate: \$ _____
 Contact: _____ Telephone: _____
 Title: _____
 State: _____ Zip: _____
 New Account(Y or N): _____ Auth Code: _____

Enter Selection
 Edit record
 Previous record
 Next record
 Exit

THE SOFTWARE BOTTLING COMPANY OF NEW YORK
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Account #: _____ Salesman: _____ Today's Date: _____

Company: _____
 Contact: _____
 Title: _____
 Address: _____
 City: _____
 Referred By: _____
 Comments: _____
 Completion Date: _____ Invoice Sent: _____ Payment Received: _____

*** POP-UP Help Screen Number One ***
 Enter data into the fields exactly as you see it here. Do not worry about making a mistake, all data is error-checked as it is entered. It is impossible to make a mistake!

ABC Roofing Company
 Job Estimation and Control Program

Enter Job Description

You Will Need The Following Parts

Part Number	Amount Needed	Amount Available	Balance This Amt

Job Number: _____
 Surface Type: _____
 Size Length: _____
 Width: _____
 Thickness: _____
 Climate: _____

Test for Selection
 Update for Selection
 Previous record
 Next record
 Exit

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QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT

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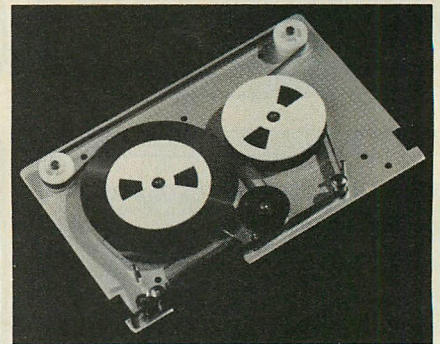
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LETTERS

The photo portrays the importance of the article on mass storage media. The tape cartridge is shown with its plastic casing removed. The photo is technically incorrect; it shows the tension belt across the top two pulleys only. In an operative cartridge this belt goes not only across the top pulleys, but also below the black capstan toward the front of the tape.

I am sure this is an oversight, as you are aware of the fact that the drive mechanism drives the capstan, which, with the help of the belt, moves the

PHOTO: Tape Cartridge



Above is the correct arrangement of the tension belt and tape on an operative tape backup cartridge.

tape. The tension belt serves multiple purposes. It moves the tape, retains tension in the tape on the hubs, and helps retain the edges of the tape on the hub.

Because the edges of the tape are not physically attached to the hubs, this last function is not really very effective if the drive electronics do not respond to BOT (beginning of tape) and EOT (end of tape) holes.

I have a theory as to how this may have occurred. Perhaps someone opened the cartridge trying to photograph individual pieces of the cartridge, and the belt was removed. The first time I removed a belt out of curiosity, it was very difficult to restore the cartridge to its original form.

Since then I have learned not to remove the belt, but if I have (from feeling adventurous), here are the steps I follow to replace it: I start from the capstan first, then place the belt on the pulley towards the hub containing most tape. Then, while holding both hubs with one hand to introduce some tension into the media itself, I stretch the belt with the other hand and install it on the last pulley.

This requires some work to acquire the proper tension in the media

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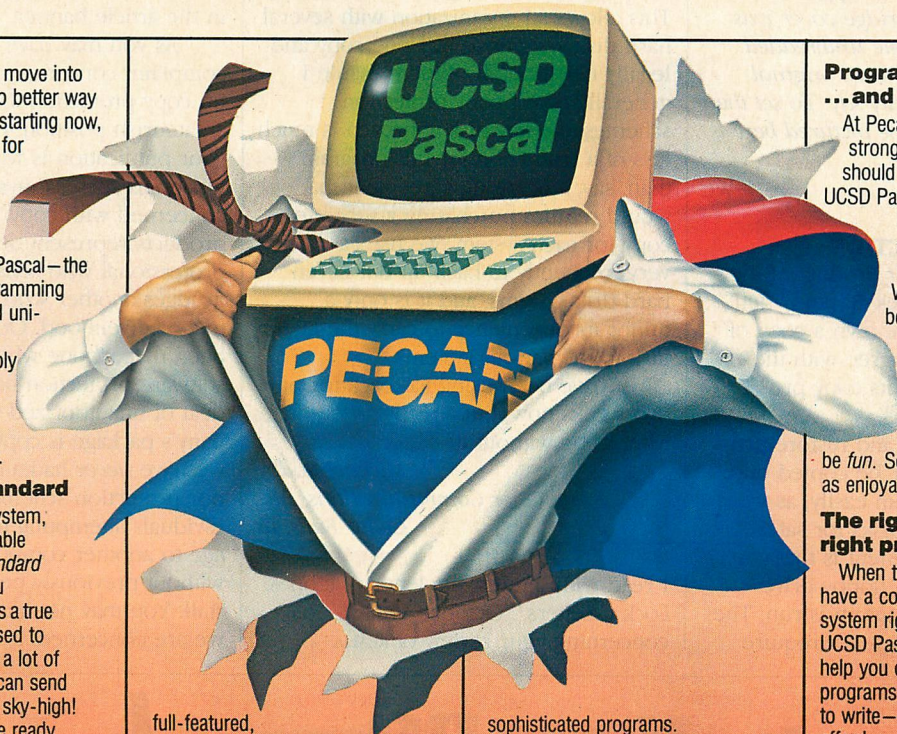
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itself before the cartridge can be installed successfully in the tape drive.

—Asad Yasin
Dayton, OH

Thank you very much for your careful scrutiny of our November cover. We checked with the photographer, and your theory about what happened is correct: when the cartridge cover was taken off, the tape came unthreaded and was not restored to its original form, as you so tactfully say. To set the record straight, the tape pictured here is in its original form.

—WF

THEIR OWN PROTECTION

Regarding the October Product of the Month, Fastback ("Sleek Backup," Jeff Duntemann, p. 31), we own a copy of the product and I disagree with the reviewer's opinion of its copy protection for two reasons.

First, the backup and restore programs themselves *can* be copied onto a hard disk to use them easily, as well as onto other floppy disks for safekeeping. The only requirement is that you have the key disk in a floppy drive when the BACKUP program is run. The RESTORE program does *not* require

this key disk. Thus, your backups are *not* lost if the key disk goes bad. This type of copy protection is not very intrusive when attached to this type of program, because backups are usually made only once a day, at most.

Second, the licensing agreement omits the normal requirement to run the programs on only one machine. This allows an organization with several hard disk systems to buy one copy and legally use it on all of them. While I generally detest copy protection schemes, the key disk approach is much less of a restriction for this program than, say, a licensing agreement that would require purchasing a separate copy for each system. We use Fastback very frequently to back up our seven hard disk systems, and it is only a minor inconvenience to carry the key disk to the various systems.

I have been using Fastback for only two weeks now, but already I wouldn't want to be without it!

Michael Rodby
Oster Communications, Inc.
Cedar Falls, IA

I read with interest the letter of John A. Lock ("Letters," October 1985, p. 15) concerning your review of REALIA

COBOL ("COBOL Performs, Ted Mirecki, August 1985, p. 107). In the 23 years I have been in this business, I have never agreed with anyone as much as I do with Mr. Lock on the product and especially its copy protection. You then reviewed Fastback and made the same negative comment about its copy protection and even placed the criticism in the article banner.

As you may have assumed, my complaint concerns your editorial stand on copy protection. I consider it an amateurish position. I would assume your publication is widely read by professionals such as myself. We are all concerned with copy protection as our products represent our survival. No professional who sells his wares begrudges another who attempts to protect his livelihood. Our experience has been that anyone who complains about software protection has acquired a great deal of unauthorized software. My company's package is copy protected and we have *never* had a call concerning our protection scheme except from individuals attempting to move the package to another computer/file server without previously performing a deinstall. You may not like that, but as far as we are concerned, it is unacceptable.

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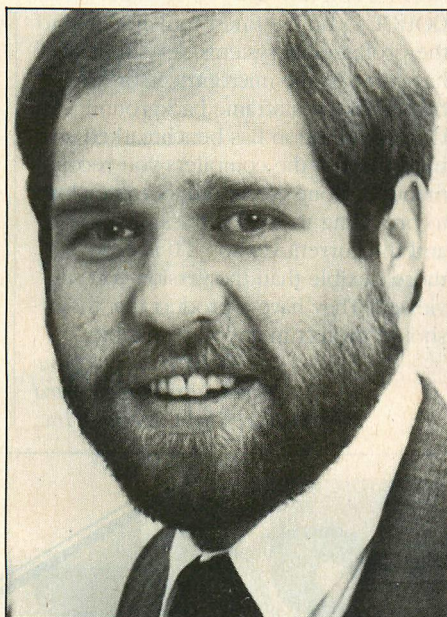
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When your organization considered the publication of this magazine, you surely considered the total size of the market and your potential market share. If your market share prediction was accurate, but was achieved by one reader in five purchasing the magazine and then loaning it to four others, I doubt I would be writing this letter to you. However, you enjoy a degree of copy protection. You have a product that can be used by only one individual at a time and there is no quick and inexpensive method of duplicating it.

Software piracy is *the* major threat to a software publisher. We all wish the computer manufacturers encoded a serial number in ROM by which we could achieve some degree of protection via hardware. While there are devices in the marketplace that do provide this type of hardware protection, none of them is inexpensive. What we are dealing with here is a matter of product cost. If the market continues to demand low-cost software products, then the publisher certainly has a right to demand a one-for-one sales ratio. Otherwise, a product such as Fastback should be priced at \$795 instead of \$149 or include a device that can add from \$75 to \$300 to the price of the product.

I do not know of one software developer who protects his package who would not send a valid user another copy overnight in case of emergency. We do and so does REALIA; they did it for us. If the combined genius of your staff has a solution so we can stay in business and continue to buy your magazine, please tell us. We have been waiting for the right answer for a long time.

Frankly, you should limit your comments to the ability of a package to perform its function accurately, quickly, and efficiently. We have never used Fastback, but concerning the REALIA compiler, we have been a user of version 1.2 and now 2.0. We consider REALIA COBOL to be the finest tool available to the professional systems developer who has come to the microprocessor arena by way of a mainframe background. Our organization has benchmarked and used most of the compilers you recommended. None of the others came close to providing us the facilities of REALIA and the current version 2.0 is even more flexible than the version you reviewed. They have a product that they should protect in any way possible.

Richard H. Crichlow
Chairman of the Board
Crichlow Data Sciences, Inc.

As your letter and Mr. Rodby's indicate, software methods of copy protection continue to generate considerable controversy. Our position is firm: it is not the protection that bothers us, it is the method. We will stand opposed to the software methods of copy protection as long as they leave the buyer at risk. And while we commend your firm and REALIA for your particular efforts on behalf of your customers, not all firms that are using copy-protection schemes are so generous or prompt.

Software-based copy-protection methods do not work. They are a waste of everyone's time and money. Our efforts should instead be directed toward convincing computer manufacturers that an embedded hardware solution is required; educating buyers is another admirable goal.

By the way, I suspect that this magazine will be vulnerable to a future optical scanning technology that will reduce the cost of the illegal copy. The difference between our product and yours is that the protection afforded by law is well-understood and agreed upon. Perhaps it is time for software vendors to work together toward the same goal.

—WF



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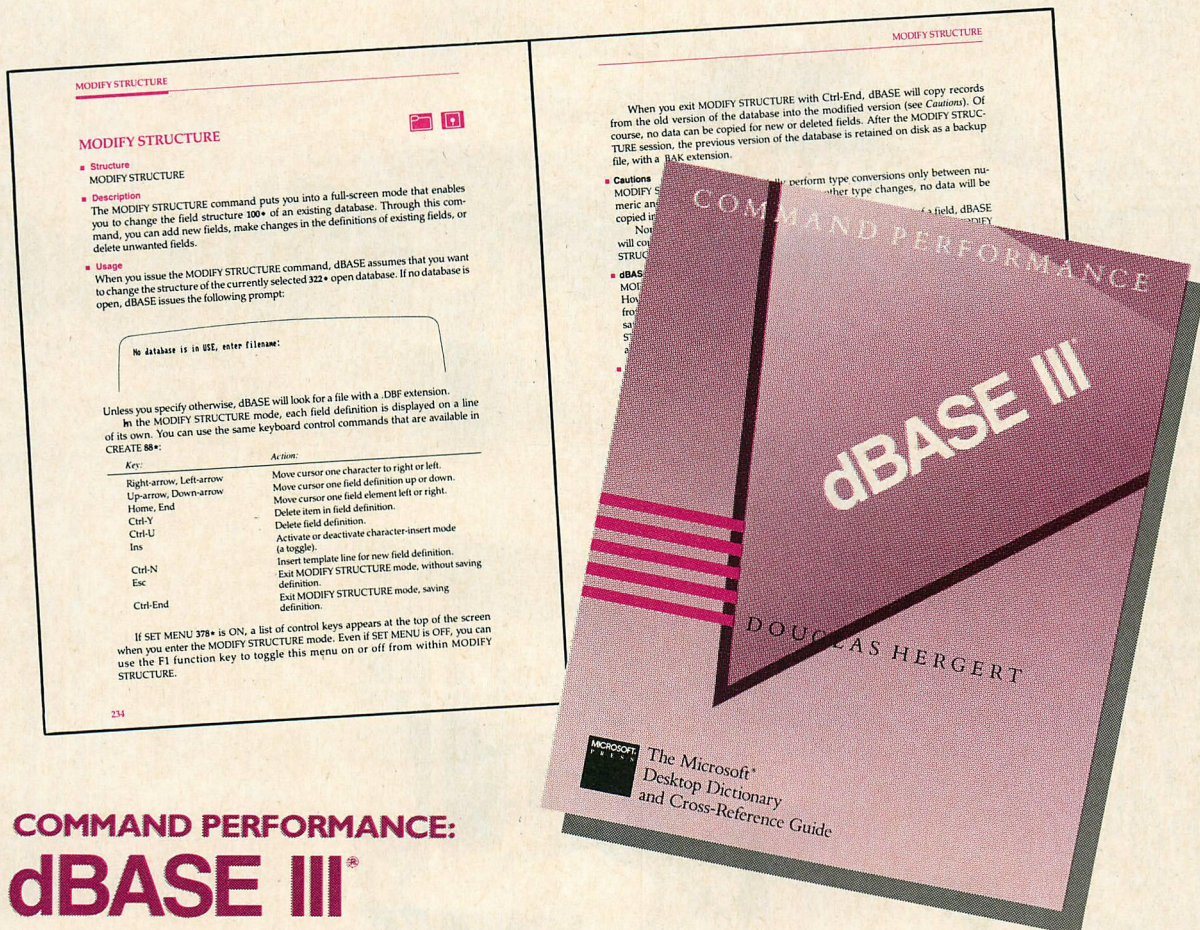
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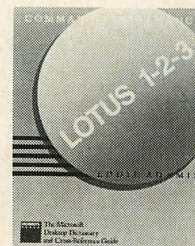
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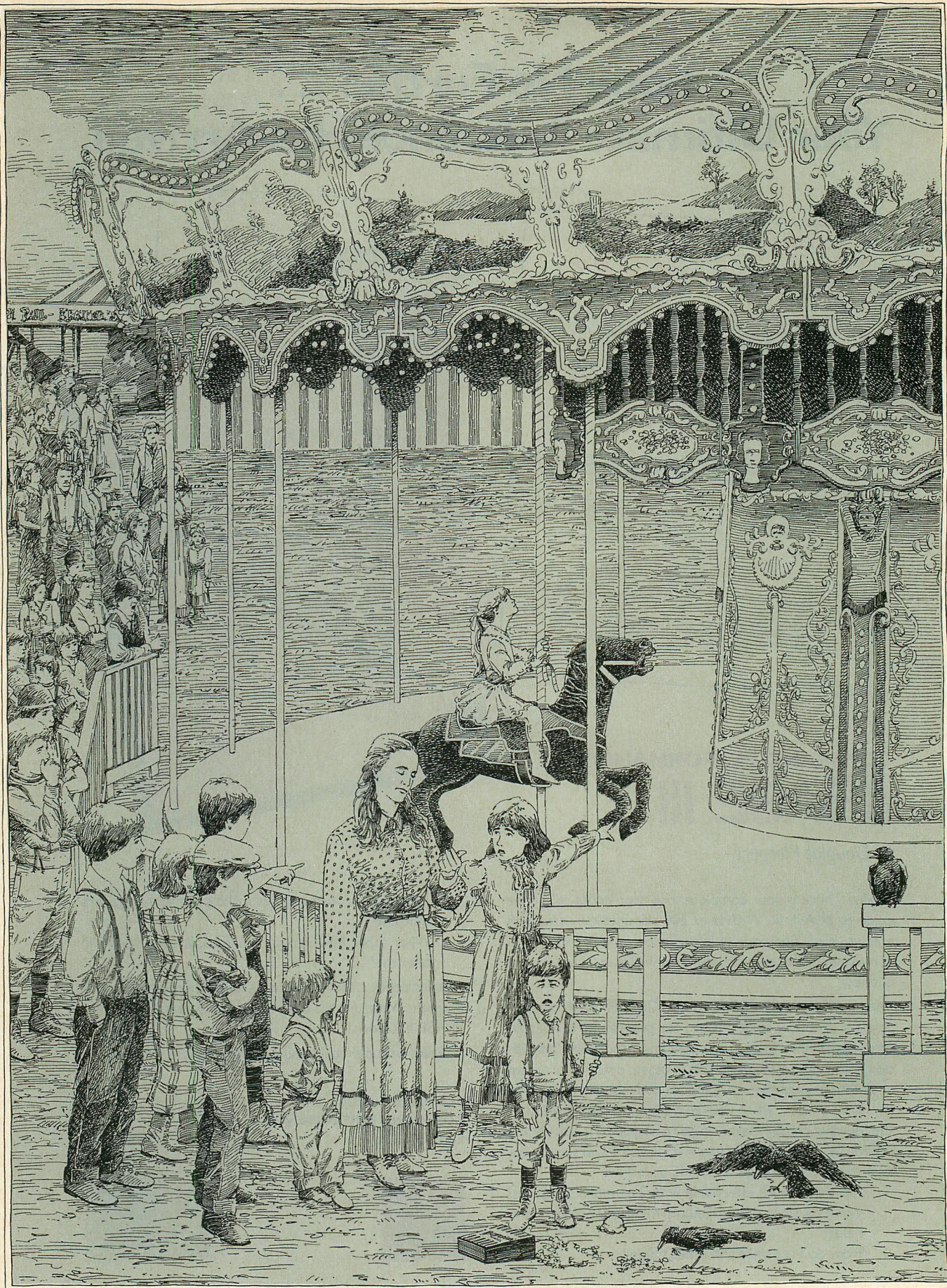
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The people who make database software have some strange logic. They tell you information is the most valuable thing in the world. And then they design their products for single-user systems. Which means that every time different people actually need to use your data, they have to stand in line for it.

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At Microrim, we have a much better idea of the way offices work. So we've developed a multi-user version of R:base 5000 that lets users update their database while other people analyze it. And we've made this new version fully compatible with our single-user version. Which means any application you develop on the single-user version today can be run on our multi-user version tomorrow.

DATAPRO RANKS R:BASE 5000 #1.

Of course, we gave the multi-user version all the features that convinced the Datapro Research Corporation to rate our single-user version as the best DBMS on the market. But we've also designed it to make optimum use of all the extra capabilities offered by the IBM PC Network (IBM PC DOS 3.1). To optimize data sharing, R:base 5000 Multi-User takes full advantage of the front end processing power of the PC. As

a result, multiple users will be able to work with the same database at the same time.

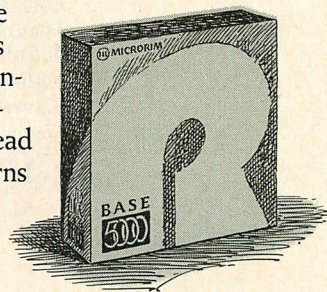
While editing, data integrity is protected by a locking mechanism that operates at the item level. This important feature lets the other users work with columns and rows of the same table. Instead of making them wait around for the other guy to finish his editing job.

SEE FOR YOURSELF: 1-800-547-4000.

The full price is \$1500, complete with three sets of documentation. But if you believe in common sense as much as we do, you won't make a decision this big till you get your hands on a copy and see for yourself. And that's just what we'd like you to do. For only \$50, we'll send you a copy of the program that has all the features, one set of documentation, and all the functionality of the full product, except for limitations on the numbers of rows, columns and tables.

Just call 1-800-547-4000 and ask for Dept. 894. From Oregon, or outside the U.S., call 1-503-684-3000, Dept. 894. Or head straight for a leading software store or computer dealer.

And see how nice it is to take advantage of information. Instead of taking turns at it.



R:BASE 5000 MULTI-USER FROM MICRORIM

IT ALL COMES DOWN TO COMMON SENSE.

If you want to run software with graphics on your monochrome monitor, we have some bad news.

As we're sure you've been told, the only way to run software with graphics on a monochrome monitor is to buy a graphics card.

For \$499, the Hercules Graphics Card runs these best-selling programs:

Ashton-Tate, *Framework*

BPS, *Overhead Express*

Lotus Development, *1-2-3, Symphony*

MicroSoft, *MicroSoft Flight Simulator, MicroSoft Word, MicroSoft Chart*

Software Products Int., *Open Access*

Software Publishing, *PFS: Graph*

Sorcim, *Supercalc 3*

In monochrome only.

And some good news.

For \$395, the Paradise Modular Graphics Card runs all these programs. In monochrome. And in color.

Arrays/Continental Software, *Ultra File*
Ashton-Tate, *Framework*
BPS, *Overhead Express*
Brightbill-Robert, *Graphix Partner*
Chang Labs, *GraphPlan*
Dow Jones & Co., *Dow Jones Market Analysis*
Lotus Development, *1-2-3*, *Symphony*
MicroPro, *Chartstar*, *Planstar*
MDBS, *Knowledge Manager*
Microsoft, *Basic Compiler*, *Basic Interpreter*, *Chart*, *Flight Simulator*, *Project*, *Word*
PC Software of San Diego, *Executive Picture Show*

Prentice-Hall, *Execuvision*
Schuchardt Software Systems, *Intecalc*,
Intemate, *Intepert*, *Inteplan*, *Inteword*
Softrend, *Aura*

Software Products Int., *Open Access*
Software Publishing, *PFS:Graph*
Sorcim, *SuperCalc 3*
Summa Software, *Winning On Wall Street*,
Trader's Forecast, *Winning On Wall Street*,
Trader's Data Manager

Advanced Ideas, *The Game Show*, *Master Match*, *Tic Tac Show*
CBS Software, *Big Bird's Special Delivery*, *Dinosaur Dig*, *Ernie's Magic Shapes*

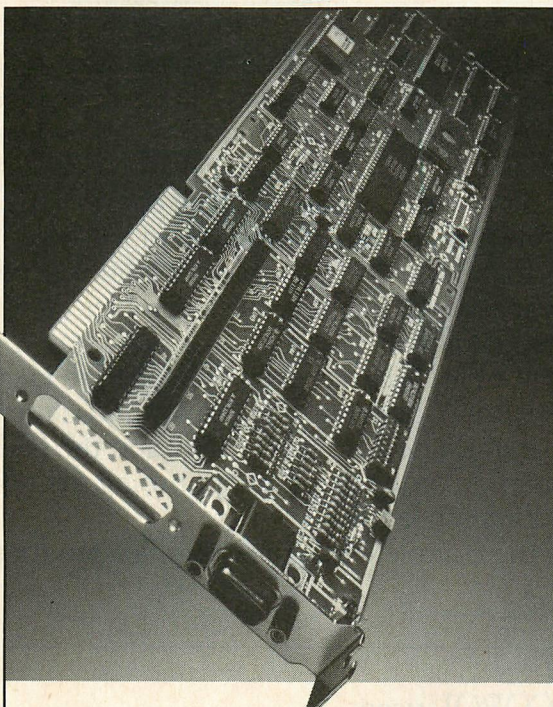
Davidson & Associates, *Math Blaster!*, *Word Attack!*
Designware, *The Grammar Examiner*, *Math Maze*, *Language Arts*, *Spellicopter*, *States & Traits*, *Trap-a-zoid*

Developmental Learning Materials, *Alien Addition*, *Alligator Mix*, *Demolition*, *Division*, *Dragon Mix*, *Meteor Multiplication*, *Minus Mission*
Eduware, *Algebra 1*, *Algebra 2*, *Algebra 3*, *Algebra 4*, *Algebra 5*

Individual Software, *Professor Pixel*, *The Instructor*, *The Typing Instructor*
Knoware, *Knoware*

Scarborough Systems, *Mastertype*, *Songwriter*
Learning Co., *Addition Magician*, *Magic Spells*,
Moptown Parade, *Number Stomper*, *Reader Rabbit*

Scholastic, *Turtle Tracks*
Sierra On-Line, *Dragon's Keep*, *Troll's Take*
Simon & Schuster, *Typing Tutor III*
Spinnaker Software, *Alphabet Zoo*, *Delta Drawing*, *Fraction Fever*, *Hey Diddle Diddle*,
Kids on Keys, *Kindercomp*, *Rhymes & Riddles*,
Story Machine



The Paradise Modular Graphics Card runs all the popular programs Hercules does, plus 150 more.

Springboard, *Early Games for Young Children*, *Make a Match*, *Piece of Cake Match*, *Quizagon*

Thoroughbred Software, *Exploring the Amazing Food Factory*, *The Fascinating Story of Cell Growth*, *How Plants Grow*, *Migrating Molecules*, *Mastering Units of Measurement*, *Photosynthesis*

Unicorn Software, *Funbunch*, *Ships Ahoy*, *Ten Little Robots*

Digital Research, *DR Logo*

Energtonics, *Energraphics*

Fox & Geller, *dGraph*, *OZ*
Graphic Communication, *Graphwriter BASIC*, *Graphwriter Combination*, *Graphwriter Extension*

Harvard Associates, *P.C. Logo*

Innovative Software, *Fast Graphs*

Mouse Systems, *PC Paint*

PC Software of San Diego, *PC Crayon*

Peachtree Software, *Business Graphics System*
Arktronics, *Jane*

Eagle Software Publishing, *Personal Financier*

Monogram, *Dollars and Sense*

Penguin Software, *Graphics Magician*

Sierra On-Line, *Homeword*

Adventure Enterprises, *Sea Dragon*

Atarisoft, *Centipede*, *Defender*, *Dig Dug*,
Donkey Kong, *Pac Man*, *Robotron*, *Stargate*

Avalon Hill Game Company, *Andromeda Conquest*, *Computer Football Strategy*, *Computer Stocks & Bonds*, *V.C.*, *Voyager*

Broderbund Software, *Serpentine*
CBS Software, *Match-Wits*, *Mystery Master: Murder by the Dozen*
Hayden Software, *Sargon III*
Innovative Design Software, *Pool 1.5*
Intelligent Statements, *Asylum*
Microlab, *Crisis Mountain*, *Death in the Caribbean*, *Dino Eggs*, *High Rise*, *Miner 2049er*
Muse Software, *Castle Wolfenstein*
Odesta, *Backgammon*, *Checkers*, *Chess*, *Odin*
Origin Systems, *Ultima III*
Orion Software, *J-Bird*
PC Software of San Diego, *Championship Blackjack*
Penguin Software, *The Quest*
Priority Software, *Forbidden Quest*
Scarborough Systems, *Buck Rogers*, *Congo Bongo*, *Star Trek*
Sentinent Software, *Cyborg*
Sierra On-Line, *BC's Quest of Tires*, *Championship Boxing*, *CrossFire*, *Dark Crystal*, *Frogger*, *King's Quest*, *Oil Well*, *Ultima II*, *Ulysses and the Golden Fleece*
Sir Tech, *Wizardry*
Sirius Software, *Buzzard Bait*
Spectrum Holobyte, *Gato*
Spinnaker Software, *Snooper Troops #1*, *Snooper #2*
Sublogic, "Night Mission" Pinball

It's true, Hercules only runs 10 of the 161 programs with graphics for the IBM PC carried by SOFTSEL®, the largest distributor of micro computer products.

Since the Paradise Modular Graphics card is 100% compatible with the IBM color graphics standard, it'll run virtually every program written for the PC. In monochrome. And in color. Now and in the future.

And we give you a \$50 trade-in allowance on your old Hercules or IBM card.

So see your dealer or call us. And get some good news for a change.

PARADISE

S Y S T E M S , I N C

CIRCLE NO. 230 ON READER SERVICE CARD

Paradise Systems Inc., 217 East Grand Ave., South San Francisco, CA 94080
(800) 822-2020 Ext. 217 (CA) or (800) 527-7977 Ext. 217 (Outside CA)

News about the Microsoft Language Family

Faster Macro Assembler 4.00 release developed in Microsoft C

By porting the new Macro Assembler 4.00 release to Microsoft C, it assembles programs from 2 to 3 times faster than the previous Microsoft 3.00 and IBM® 2.00 releases. The mixed language and memory model support unique to Microsoft C allowed the new assembler to be written as a small model program using the more efficient Pascal calling conversions for all internal functions. Macro text, symbol names and file buffers were moved out of the 64K "near" workspace into "far" memory allowing much larger programs to be assembled. Additional performance tuning was possible in C by using register variables throughout the assembler. Final profiling identified a few critical small routines to write in assembly language.

The source symbolic debugger, SYMDEB, has been enhanced to include screen swapping, stack backtracing, DOS command execution, better source display and debugging features making this the ideal tool for debugging programs. The 25% faster LINK and the EXEPACK utility can compress executable files by removing common sequences and optimizing the relocation tables. The MAKE utility now supports macros and inference rules.

We are committed to making the complete Macro Assembler product the best value in PC development tools.

News for Microsoft and IBM COBOL users

The new Microsoft® COBOL 2.1 release for MS-DOS® and XENIX® features faster execution and support for the new COBOL Tools package which contains VIEWCOB, COBREF, Menu Handler, and CBMOUSE (MS-DOS only). VIEWCOB is an interactive symbolic debugger with an easy-to-learn, menu-driven user interface which supports on-line help and up to 10 windows on your source text, variables, memory, and procedure traces. The COBOL trace mode highlights each statement as it is executed. COBREF is an advanced COBOL cross reference generator that displays lists of files, variables with types, and procedures. Menu Handler and CBMOUSE allow the COBOL programmer to create menu-driven applications to interface to the Microsoft Mouse.

Microsoft C Selected for the IBM personal computer C compiler

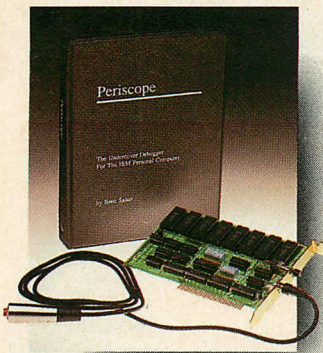
The IBM C compiler is a repackaging of the Microsoft C Compiler with a few utilities from the Microsoft Macro Assembler product. A XENIX version of the same compiler is part of Microsoft's XENIX system V release. IBM also distributes Microsoft BASIC, COBOL, FORTRAN, and Pascal compilers, BASIC interpreter and Macro Assembler under its own logo. Microsoft offers special upgrade pricing to owners of certain Microsoft languages purchased through IBM. Call us for more information.

Write to: MICROSOFT Languages Newsletter
10700 Northup Way, Box 97200
Bellevue, WA 98009 for product update and information.

Or phone:
(800) 426-9400. In Washington State and Alaska,
(206) 828-8088. In Canada, call (416) 673-7638.

Latest DOS Versions:

C	3.00
COBOL	2.10
FORTRAN	3.31
Macro Assembler	4.00
Pascal	3.31
QuickBASIC	1.00



Structured Debugging

Data Base Decisions' Periscope I and II offer considerable power and a variety of options for professional debugging at economical prices.

The greater part of knowing what's going wrong is simply knowing what's going on. Once most professional programmers see a problem, they already know how to solve it.

Debuggers were created to provide a view into program internals. Because they also are programs, however, debuggers can be destroyed by unruly behavior on the part of the program being observed. Low-end debuggers (DOS DEBUG, for example) simply take their chances. High-end debuggers provide a hardware solution in the form of a write-protected memory board in which debugger code and data reside. Once the decision is made to require the use of a bus slot, high-end debugger vendors traditionally have added other features to the memory board, such as true hardware breakpoints, to make the occupation of the slot worthwhile. This elaborate hardware support puts the price of such debuggers (generally around \$1,500) out of the reach of all but the commercial program developer.

Between these two extremes lies room for compromise: a well-engineered debugger, for example, with simple hardware support limited to protected RAM and an NMI (nonmaskable interrupt) trigger or "breakout switch." Such a product would require a slot, but would not have to be expensive, and would be immune to destruction by runaway software under development. In providing such a compromise, Data Base Decisions' Periscope merits recognition as the *PC Tech Journal* January Product of the Month.

Periscope's most noteworthy feature is its protected memory board, whimsically named the Submarine. It contains 8KB of static RAM, a push-button switch on the board bracket, and an RCA jack for a remote switch on a cable. When pressed, either switch generates an 8086 NMI which, once Periscope has been loaded, always returns program control to the debugger.

The Submarine's static RAM is independent of the PC's refresh controller and cannot be written to except through an I/O port. It provides only enough RAM to contain critical code and data (a good portion of Periscope resides in ordinary RAM), but protects enough to enable Periscope to recover from any crash that has not corrupted interrupt vector 2.

Periscope I (with Submarine) is available without the protected RAM board; Periscope II includes a breakout switch that does *not* require an expan-

PRODUCT NAME

Periscope I and Periscope II

COMPANY

Data Base Decisions

ADDRESS

14 Bonnie Lane
Atlanta, GA 30328

TELEPHONE

800/722-7006; 404/256-3860

sion slot for installation. Periscope II is less crash-resistant than Periscope I, but it is also half the price.


The Periscope software (the same for I and II) builds on the debugging standard of IBM DEBUG. All 8086/88 and 80286 real mode opcodes are supported; protected virtual mode is not. The basic commands for entering and clearing breakpoints, dumping and altering memory, and disassembling and assembling code in place are there. Periscope adds every conceivable type of breakpoint: on register values, software interrupts, byte and word values for a given address, input and output port access for one port or a range of ports, source line numbers when debugging high-level language programs, and access to a given memory location or range of locations. It allows the incorporation of user-written breakpoint

tests for conditions it does not usually trap; for example, a trap could be written to test for a wraparound condition on a communications ring buffer.

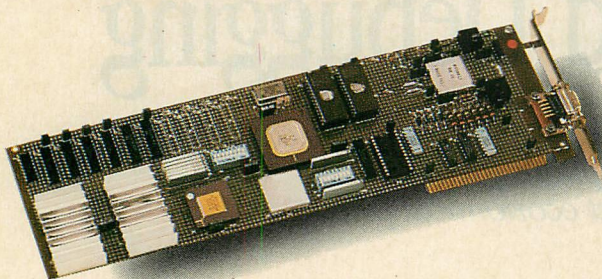
Memory dumps are easy to read. Periscope can display blocks of memory formatted as bytes, words, double words (pointers), or as signed or unsigned integers. This was the first debugger to allow the combination of these formats into a display format record that allows display of an area of memory as logical fields, as in a PSP, FCB, or a Pascal or COBOL data record. The PSP and FCB formats are supplied; users can write their own as easily as editing an ASCII definition file. The effective address of any read or write operation also can be displayed.

The only use of DOS by Periscope is for file I/O. DOS itself thus can be traced without reentry problems, making the debugging of DOS device drivers much simpler. Non-DOS applications also can be debugged.

Periscope's own design and execution are highly professional. It offers many configuration options, including a few that avoid RAM and I/O conflicts with the EGA (Enhanced Graphics Adapter), but all of these are clearly explained both in the manual and in an optional set-up menu. The software appears to be bug-free and moves screens around with lightning speed.

Periscope is not in the same class with true hardware-breakpoint debuggers, such as Atron's PC Probe (which costs \$1,595). The Atron product can trace in realtime; Periscope pays a considerable performance penalty because its breakpoints and single-stepping machinery all must be done in software. It is closer in concept to IBM's Professional Debug Facility, which it outclasses in almost all respects. However, for \$295 with the Submarine board and \$145 without, Periscope strikes a balance of power and features that will please serious PC programmers. 

Hardware, software, and other developments for the IBM PC family



IBM Token-Ring Network adapter card



IBM PC/AT with 30MB fixed disk

FROM IBM

IBM Corporation has announced a new version of the **PC/AT** that allows users to store more than 60 million characters of information. The new AT features a 30MB fixed-disk drive and comes with 512KB of user memory and a 1.2MB diskette drive. A second 30MB fixed-disk drive also may be installed (a kit is available to upgrade existing ATs with the 30MB fixed-disk drive). The company also announced that the additional fixed-disk drive storage capacity now is available on the IBM PC/AT-370. PC/AT with 512KB/1.2MB diskette drive and 30MB fixed-disk drive, \$5,995; 30MB fixed-disk drive option, \$1,995; 30MB AT upgrade kit, \$1,995; PC/AT-370 with 512KB/1.2MB diskette drive and 30MB fixed-disk drive, \$9,995.

IBM Corporation, Entry System Division, P.O. Box 1328, Boca Raton, FL 33432; Contact the local IBM dealer

CIRCLE 301 ON READER SERVICE CARD

IBM also has announced the **Token-Ring Network** to connect information processing equipment within a building or in a campus environment. It offers SNA emulation, an asynchronous gateway, a LAN-to-LAN bridge, an IBM Series/1 gateway, a high-performance print server, and NETBIOS functions. The company has extended the specifications of the **IBM Cabling System** to include unshielded telephone twisted pair wiring, allowing customers to use already installed telephone cable to connect certain devices, including those on a token-ring LAN. The applications program interface, **Advanced Program-to-Program Communications for the PC** (APPC/PC), is based on the company's SNA LU 6.2 interface. APPC/PC can be used for peer-to-peer communication between PCs and SNA-based host computers. Token-Ring Network includes adapter card and diskette, \$695;

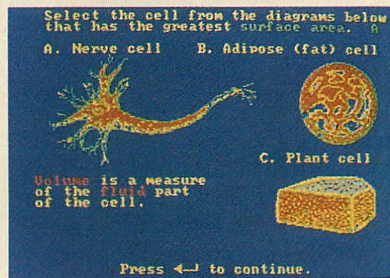
Multistation Access Unit, \$660; adapter cable, \$35. One-time license charge for Token-Ring NETBIOS program, \$35; Token-Ring LAN/PC Network Interconnect program, \$495; IBM Asynchronous Communications Server program for the Token-Ring and PC Networks, \$495. APPC/PC, \$150.

The **Personal Computer C compiler** is a new program designed primarily for systems and applications programmers writing C software for microcomputers. It can be used with the IBM PC-DOS and the IBM PC Network. \$495.

In addition, ten new **educational programs**, including six additions to the company's biology series and four to the physics series have been announced. \$65 to \$75 each.

IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573. Contact the local IBM dealer

CIRCLE 303 ON READER SERVICE CARD



IBM biology program screen

The **IBM PC-3278/79 emulation adapter** allows the AT to attach to control units through coaxial cable and operate as interactive display stations in large computer systems. When used with the IBM PC-3278/79 emulation control program version 2, the adapter allows an AT to emulate an IBM 3278 display station or an IBM 3279 color display station. This provides access to files and applications on IBM System/370 host computers. Both the host-controlled session and a local PC-DOS ses-

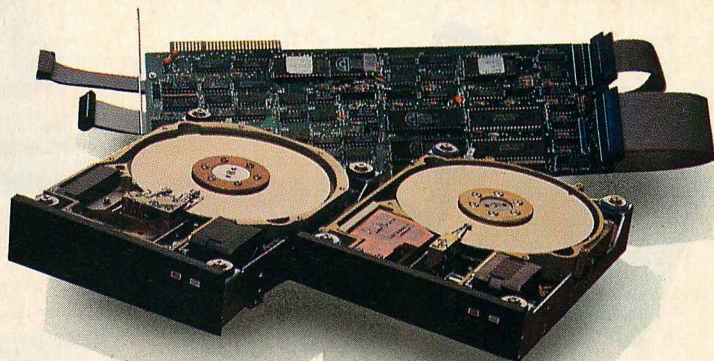
sion can run concurrently, and the user can switch between sessions. PC-3278/79 emulation adapter package, \$1,140; PC-3278/79 emulation control program version 2 (one-time charge), \$235.

The **IBM 3708 network conversion unit** is a protocol converter that enables asynchronous/ASCII terminals to communicate with host computer systems that use IBM's SNA/SDLC protocol. The 3708 has 10 ports for attaching host computers or incoming lines of asynchronous/ASCII data from devices such as PCs, printers, and plotters; it converts the data stream from ASCII to SNA/SDLC protocol and 3270 full-screen data format. It then concentrates the data onto outgoing lines for transmission to S/370 host computers. \$4,500.

Enhancements to the **IBM 3710 network controller** provide the same ASCII-to-SNA/SDLC protocol conversion capabilities for 3710 users. Up to seven adapters can be installed in a single 3710 for as many as 56 ASCII device ports. 8-port communications adapter, \$3,300. The new **IBM 3299 model 2 terminal multiplexer** connects IBM 3270 series terminals to IBM 3274 control units and IBM 4361 workstation adapters at distances of up to 6,000 feet using IBM cabling. \$1,175.

The host-based **IBM Displaywrite/370 program product** enables users to create, revise, and print documents and messages on large IBM computers. This information can be exchanged with other IBM computers and workstations that have DisplayWrite. Displaywrite/370 editing functions are similar to those of previously announced IBM office systems family programs and are designed for use on 3270 terminals or IBM PCs with 3270 emulation. MVS and VM versions, \$14,000 each; VSE version, \$6,000. *IBM Corporation, Information Systems Group, National Accounts Division, 1133 Westchester Avenue, White Plains, NY 10604; 914/696-1900*

CIRCLE 302 ON READER SERVICE CARD



By The Torrington Company

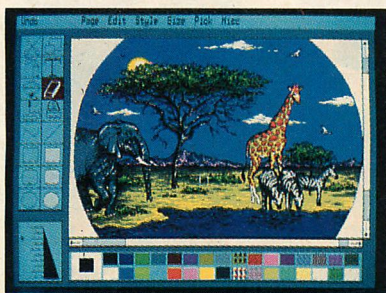
Microscience EasyStor

HARDWARE

Version 5.0 of the **Microsoft Mouse** has been announced by **Microsoft Corporation**. It features improved ergonomic design, higher resolution (from 100 ppi to 200 ppi), and near-silent operation on all surfaces. Teflon runners and a rubber-coated control ball have replaced the steel components. Version 5.0 comes bundled with productivity software, including a new version of PC Paintbrush that allows users to choose commands from pull-down menus. The mouse is offered in either a serial or bus version. Serial version, \$195; bus version, \$175.

Microsoft Corporation, 10700 Northrup Way, Box 97200, Bellevue, WA 98009; 800/426-9400; in Washington, 206/828-8080

CIRCLE 306 ON READER SERVICE CARD



PC Paintbrush with Microsoft Mouse

Maynard Electronics has introduced the **Maynard Mouse**. With its Custom-Key supporting software, the mouse lets the user assign numerous customized commands while running his favorite programs, and will work with all popular software, even those that do not supply mouse utilities. The user can create macros during program use. Additional features include optional button click, combination alternate cursor commands, cursor speed control, on-line

help, and confirmation menus. The mouse has twin-wheel suspension which works smoothly on any surface; it includes its own special port, leaving the serial port usually required for mouse installation free. \$185.

Maynard Electronics, 460 E. Semoran Blvd., Casselberry, FL 32707; 305/331-6402

CIRCLE 307 ON READER SERVICE CARD

An alternative of ball and optical mice has been introduced by **The Torrington Company**. This new product, called **Manager Mouse**, features a unique independent suspension system, an on-board microprocessor, and a self-contained drive mechanism. The TMouse software bundled with the mouse provides compatibility with a wide range of software products for windowing, CAD and graphics operations, project management, and word processing. Manager Mouse does not require a separate power supply or special tablets. \$198; with the standard connector required for PC/AT, \$228.

The Torrington Company, 59 Field Street, Torrington, CT 06790-4942; 800/982-0030; 203/482-9511

CIRCLE 308 ON READER SERVICE CARD

Microscience International Corporation has introduced a new line of complete disk drive systems. The new **EasyStor 10** and **EasyStor 20** are fully integrated and fully tested hard-disk systems designed to meet the expanded storage needs of PC and PC-compatible users. Respectively offering 10MB and 20MB of storage, the systems include a half-height 5¼-inch Microscience Winchester disk drive, advanced hard-disk controller, interconnecting cables, and installation/operating manual. EasyStor 10, \$1,095; EasyStor 20, \$1,295.

Microscience International Corporation, P.O. Box 7575, Mountain View, CA 94043-7575; 415/961-2212

CIRCLE 300 ON READER SERVICE CARD

The **Companion Card** was designed by **Mega-Omega Systems, Inc.** to meet the Intel/Lotus/Microsoft expanded-memory specification. It can fill in conventional memory below 640KB, then add expanded workspace memory above 640KB as applications grow. As much as 4MB can be addressed beyond 640KB. The Companion Card includes a print buffer, RAM disk, and menu-driven installation programs. Its diagnostics feature checks for defective memory chips. The **Companion Card Plus** adds a serial port, a parallel port, a game port, and a realtime clock. Companion Card: 0KB, \$295; 256KB, \$395; 512KB, \$495; 768KB, \$595; 1MB, \$695; 2MB, \$1,090. Companion Card Plus: 0KB, \$495; 256KB, \$595; 512KB, \$695; 768KB, \$795; 1MB, \$895; 2MB, \$1,290. Battery back-up unit, \$295.

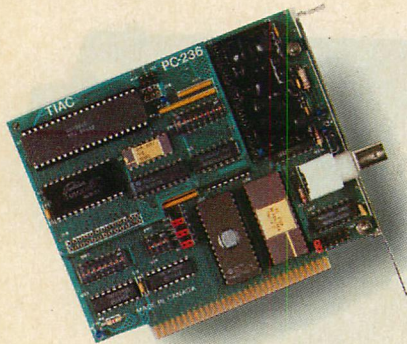
Mega-Omega Systems, Inc., 5217 Ross Avenue, Suite 710, LB 122, Dallas, TX 75206; 214/828-0960

CIRCLE 318 ON READER SERVICE CARD

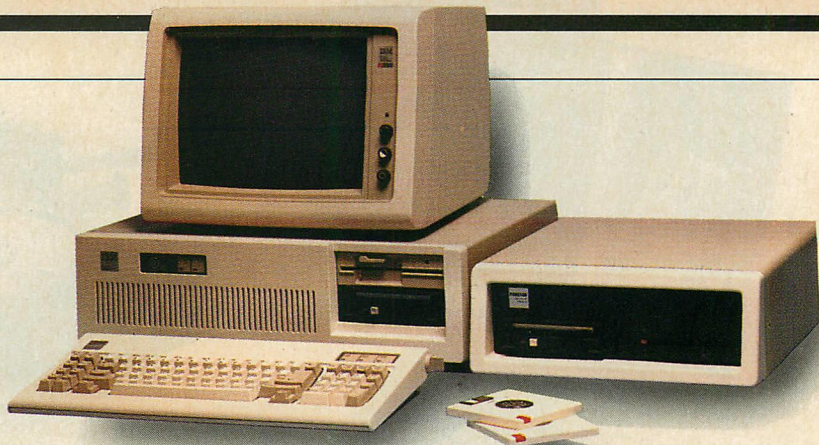
GEODISK is a product line based on CDROM technology by **GEOVISION, INC.** It will place geographic images and data for a particular region that is referenced by the standard coordinate grid system. As a read-only reference system, discs will be refreshed periodically while users can create, store, and maintain facility, boundary, or engineering records and graphics in an independent but totally compatible database. The **GEODESK** workstation product is based on popular computer hardware enhanced by special cards, software, and a 550MB CDROM laser drive system. The current product is built around a PC/XT equipped with a 10MB hard-disk and 360KB floppy-disk drive, 640KB RAM, and high-resolution color graphics capability. Single user unit, \$25,000.

GEOVISION, INC., Suite 135, 303 Technology Park/Atlanta, Norcross, GA 30092; 404/448-8224

CIRCLE 304 ON READER SERVICE CARD



TIAC's PC-236 ARCNET LAN

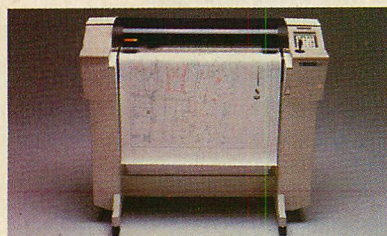


Perstor storage system

CalComp has added three models to its 1040 series of pen plotters. Key features include an eight-pen turret with automatic pen capping and full-width plotting capability up to ANSI size E or ISP size AO. Model **1043GT** performs in cut-sheet mode only; models **1042GT** and **1044GT** are dual-mode plotters that operate in cut-sheet and roll-feed modes. The 1042GT achieves a 200-percent increase in throughput speed, while the 1043GT and 1044GT achieve 60-percent increases. The plotters offer RS-232, RS-449, and IEEE-488 interfaces. With the **Plot Manager** firmware, any CAD/CAM system or graphics application package that drives the plotters can produce optimized plots with no software development effort or additional processing load. 1042GT, \$11,900; 1043GT, \$8,905; 1044GT, \$13,900.

Calcomp, 2411 W. La Palma Avenue, Anaheim, CA 92801; 714/821-2142

CIRCLE 310 ON READER SERVICE CARD



CalComp's 1040GT series plotter

TIAC Manufacturing Inc. has introduced a 255-node, 2.5-megabaud token-passing LAN for the PC, PC/XT, and PC/AT. The **PC-236** features fault-tolerant architecture with sockets provided for both JEDEC memory expansion (32K EPROM or 8K RAM) and DES encryption. It is fully compatible with Data-point Corporation's ARCNET LAN at the link layer. \$395.

TIAC Manufacturing Inc., 3080 Spring Street, Port Moody, British Columbia, V3H 1Z8, Canada; 604/461-1626

CIRCLE 362 ON READER SERVICE CARD

Perstor (for personal storage) is a family of high-capacity, high-performance fixed disks and portable hard-disk cartridge systems for the PC, PC/XT, and PC/AT manufactured by **Systems and Software, Inc.** A 12MB removable hard-disk cartridge drive or a 26MB, 32MB, 53MB, 85MB, or 140MB fixed-disk drive can be installed internally or can be combined in an external model to offer up to 280MB of fixed storage or 24MB of removable storage capacity. The Perstor **Controller Card** gives the user total compatibility with all IBM software and guarantees interchangeability between comparable machines using the hard-disk removable cartridge; it will support four hard-disk drives. Installation and continuing service contracts are available. Prices start at \$1,647. *Systems and Software, Inc. 7825 E. Redfield Road, Scottsdale, AZ 85260; 602/948-7313*

CIRCLE 320 ON READER SERVICE CARD

A five-chip set that replaces 63 SSI, MSI, and LSI circuits on the PC/AT motherboard has been introduced by **Chips and Technologies, Inc.** The **CHIPSet** offers 8-mHz operation with one wait state using 150-ns DRAMS and 200-ns EPROMS, a programmable option of zero to four wait states, the capability to address different on-board memory configurations, and a 10-mHz system clock operation. \$72.40 in quantities of 100.

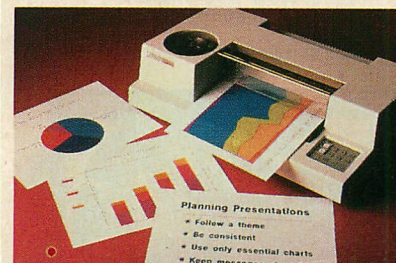
The company also introduced a four-chip set, the **Enhanced Graphics CHIPSet**, that provides a compatible solution to the IBM Enhanced Graphics Adapter. Through higher integration and 256KB DRAM support, the set reduces the chip count from 76 to 32. The package includes the CHIPSet, 256KB of DRAM, 16KB of EPROM/PROM, and SSI/MSI devices. \$85.40 in quantities of 100. *Chips and Technologies, Inc., 521 Cottonwood Drive, Milpitas, CA 95035; 408/434-0600*

CIRCLE 311 ON READER SERVICE CARD

Hewlett-Packard Company has introduced the **HP ColorPro** eight-pen plotter. Designed for reports and presentations, the ColorPro produces multicolor pie, bar, and line graphs and text charts on 8½-by-11-inch overhead-transparency film and paper; its .001-inch resolution allows the plotting of solid areas of color and continuous straight lines. A ROM cartridge slot permits adjustment to emerging graphics standards; an available graphics enhancement cartridge adds advanced capabilities, including a larger buffer and more advanced commands. \$1,295; graphics enhancement cartridge, \$195.

Hewlett-Packard Company, 1820 Embarcadero Road, Palo Alto, CA 94303; Contact the local HP dealer

CIRCLE 309 ON READER SERVICE CARD



HP ColorPro plotter

Informatics General Corporation and **Micro Tempus Inc.** have agreed to exchange micro-to-mainframe linkage technology. Their joint product, **Alpha/Link**, lets PC users access IBM mainframe-based virtual disks with PC-DOS or MS-DOS commands. \$6,200 for a five-microcomputer site license.

Informatics General Corporation, Corporate System Division, 21050 Vanowen Street, Canoga Park, CA 91304; 818/716-1616

CIRCLE 372 ON READER SERVICE CARD

Micro Tempus Inc., 440 Dorchester Blvd. W, Suite 300, Montreal, Quebec, H2Z 1V7, Canada; 514/397-9512

CIRCLE 315 ON READER SERVICE CARD

SAVE OVER 30% ON OUR GIFT PACKS!
60-DAY MONEY-BACK GUARANTEE

How Borland's Three New Holiday Packs Will Fill Your Stocking Without Emptying Your Piggybank.

Three special packs with dazzling discounts that will help get you into a Holiday mood. You can get some of Turbo, most of Turbo, or all of Turbo—including the two newest members of the Turbo family, Turbo GameWorks™ and Turbo Editor Toolbox™. You also get our unmatched 60-day money-back guarantee, quality products that aren't copy-protected.

TURBO NEW PACK \$95.00.

You get the two exciting new members of the Turbo Pascal family,

- **TURBO GAMEWORKS**, Chess, Bridge, and Go-Moku, complete with source code and a 200-page manual.
- **TURBO EDITOR TOOLBOX**, all the building blocks to make your own editors and word processors, complete with source code and a 200-page manual.

TURBO HOLIDAY PACK \$125.00.

You get all three of the Turbo family classics for only \$125.00 (about a 30% discount). Turbo Pascal 3.0 and Turbo Tutor and Turbo DataBase Toolbox—all for just \$125.00.

- **TURBO PASCAL** combines the fastest Pascal compiler with an integrated development environment.
- **TURBO TUTOR** teaches you step-by-step how to use Turbo Pascal with commented source code for all program examples on diskette.
- **TURBO DATABASE TOOLBOX** offers three problem-solving modules for your Turbo Pascal programs: Turbo Access, Turbo Sort, and GINST, which generates a ready-to-run installation program that lets you forget about adapting your software to specific terminals.

TURBO HOLIDAY JUMBO PACK \$245.00.

This is it—the whole thing, the entire Turbo family including its two newest members. You get:

- Turbo Pascal
- Turbo Editor Toolbox
- Turbo Tutor
- Turbo DataBase Toolbox
- Turbo GameWorks **NEW!**
- Turbo Editor Toolbox

and you pay only \$245.00 for all six! Which means that you're getting everything at only about \$40 a piece. Quite a holiday deal. (And if you already own one or several members of the Turbo family, be creative—nothing can stop you from buying the Jumbo Pack, picking out the ones you already have and giving the rest as holiday gifts to family and friends. At these prices you can afford to give to others and to yourself.) Speaking of Holidays, this offer lasts until March 31, 1986. (At Borland, we like to make the Holidays last.)



4585 SCOTTS VALLEY DRIVE, SCOTTS VALLEY,
CA 95066 PHONE (408) 438-8400 TELEX 172373

CIRCLE NO. 250 ON READER SERVICE CARD

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Turbo Pascal and Turbo Tutor are registered trademarks and Turbo DataBase Toolbox, Turbo Graphix Toolbox, Turbo Editor Toolbox, Turbo GameWorks, and MicroStar are trademarks of Borland International, Inc. WordStar is a trademark of MicroPro International Corp. Multi-Mate is a trademark of Multi-Mate International Corp. Microsoft is a registered trademark and Word is a trademark of Microsoft Corp. WordPerfect is a trademark of Software International.



NEW!

TURBO GAMEWORKS \$69.95.

Our new Turbo GameWorks offers games you can play and replay without Turbo Pascal or revise and rewrite with Turbo Pascal 3.0. We give you the source code, the manual, the diskettes and the competitive edge. Chess, Bridge and Go-Moku. State-of-the-art games that let you be player, referee, and rules committee all at once because you have the Turbo Pascal source code. Learn exactly how the games are made—so you can go off and make your own. And Turbo GameWorks is the only quality game you can buy that is not copy-protected. Sold separately, only \$69.95. (Just \$47.50 if you buy the Turbo New Pack.)

NEW!

TURBO EDITOR TOOLBOX \$69.95.

Build your own word processor—for only \$69.95!

You get ready-to-compile source code, a full-featured WordStar™-like word processor, and a 200-page manual that tells you how to integrate the editor procedures and functions into your programs. With Turbo Editor Toolbox, you can have the best of all word processors. You can make WordStar behave like Multi-Mate. Support windows just like Microsoft's Word. And do it as fast as WordPerfect does it. Incorporate your new "hybrids" into your programs to achieve incredible control and power. Sold separately, only \$69.95. (If you buy the Turbo New Pack, the price drops to just \$47.50.)

Holiday Gift Packs, Turbo GameWorks™ & Turbo Editor Toolbox™

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Available at better dealers nationwide. Call (800) 556-2283 for the dealer nearest you. To order by Credit Card call (800) 255-8008, CA (800) 742-1133.

Make checks payable to:
Borland International.

The holiday packs include an upgrade coupon for both options so you get BCD and 8087 support for \$39.95 (regularly \$55.00).

Carefully describe your computer system!

Mine is: ☐ 8-bit ☐ 16-bit

I use: ☐ PC-DOS ☐ MS-DOS

☐ CP/M-80 ☐ CP/M-86

My computer's name and model is: _____

The disk size I use is: ☐ 3 1/2" ☐ 5 1/4" ☐ 8"

Name: _____

Shipping Address: _____

City: _____ Zip: _____

State: _____ Telephone: _____

NOTE: Turbo Editor Toolbox and Turbo GameWorks are available for the IBM PC and true-compatibles using Turbo Pascal 3.0 ONLY.

***Gift Pack Offers Last
Until March 31,
1986**

	Quantity
* Turbo Holiday Jumbo Pack	\$245.00
* Turbo Holiday Pack	\$125.00
* Turbo New Pack	\$95.00
Pascal	\$109.90
Pascal w/8087	\$109.90
Pascal w/BCD	\$124.95
Pascal w/8087 and BCD	\$54.95
Turbo DataBase	\$54.95
Turbo Graphix	\$34.95
Turbo Tutor	\$69.95
Turbo Editor	\$69.95
Turbo GameWorks	\$69.95

These prices include shipping to all U.S. cities. All foreign orders add \$10 per product ordered.

Amount: (CA add 6% tax) _____

Payment: ☐ VISA ☐ MC ☐ Check ☐ Bank Draft

Credit Card Expiration Date: _____

Card # _____

COD's and Purchase Orders will not be accepted by Borland International. California residents: add 6% sales tax. Outside USA: add \$10 and make payment by bank draft, payable in U.S. dollars drawn on a U.S. bank. H6



R-base 5000 runtime system



By Ansa Software

Seattle Telecom & Data, Inc. has announced **TOP BOARD**, a memory-expansion board that conforms to the Lotus/Intel/Microsoft specification. Available in two versions, one using 256K RAM for 2MB on board, the other using 1 megabit RAM for 8MB on board, TOP BOARD can run stand-alone going through the 8-bit bus of the PC/XT or with ST&D's PC-286 accelerator board to run on a 16-bit wide bus, bypassing the 8-bit bus. This allows the board to run at the same clock speed as the PC-286 board. Software packages run five to six times faster. TOP BOARD can be coupled with a second board for 4MB or 16MB of expanded memory. With 256KB, \$495; 512KB, \$695; 1MB, \$1,095; 2MB, \$1,895. *Seattle Telecom & Data, Inc., 2637 151st Place NE, Redmond, WA 98052; 206/883-8440*

CIRCLE 319 ON READER SERVICE CARD

Storage, recall, and transmission of color video is now available from **Widcom Inc.** An image-compression device, the **Rapics 500**, along with any personal computer and standard telephone modem, can retrieve a color television picture stored on any other computer system from a remote location, and display it on a television monitor in less than 10 seconds. The Rapics 500 is designed for automatic *dynamic compression*, which means that it analyzes each image, selecting the best resolution, clarity, and compression ratio. A 5¼-inch floppy disk can hold as many as 100 compressed television quality color images. A 10MB Winchester hard disk can store more than 2,500 images. Widcom's optional copy stand, with color television camera and zoom lens, is available for inputting slides, photos, graphics, and charts to the Rapics/PC system. \$4,500; copy stand, \$4,500. *Widcom, Inc., 1500 E. Hamilton Avenue, Campbell, CA 95008; 408/377-9981*

CIRCLE 321 ON READER SERVICE CARD

SOFTWARE

Ansa Software, a new company backed by two major venture capital firms, has introduced **Paradox**, a relational database manager that uses practical concepts from artificial intelligence. Paradox is designed around four aspects: tables, forms, queries, and reports. The number of tables is limited only by disk space; each table (file) can contain 260 million characters in 65,000 rows (records) and 255 columns (fields) (4,000 characters per row, 255 characters per column). Query forms are used to retrieve, select, or perform calculations on the information in the tables. Paradox comes with a full-function programming language called Paradox Application Language (PAL). \$695.

Ansa Software, 1301 Shoreway Road, Belmont, CA 94022; 415/595-4469

CIRCLE 322 ON READER SERVICE CARD

Microrim, Inc. has introduced the **runtime package** for **R-base 5000**. The runtime package allows an R-base 5000 application to be run in a locked-down mode that prevents unwanted changes in that application. Access or modification of the database outside of the application is not allowed. End users may execute applications but cannot create or modify database definitions. Package of five complete runtime products, \$450.

Microrim, Inc., 3380 146th Place SE, Bellevue, WA 98007; 206/641-6619

CIRCLE 328 ON READER SERVICE CARD

InfoLok, a data security software package, has been introduced by **InfoCode, Inc.** InfoLok protects sensitive information or data by encryption translation of stored or transmitted information into unreadable code. InfoLok has four separate functions: encryption/decryption, file purging, teleformatting, and file hiding/finding. Based on algorithms, InfoLok's encryption process uses a

passkey of as many as 64 characters to transform data files to meaningless characters. The same passkey returns the files to readable text. Encryption or decryption of 100,000 bytes takes six seconds on a PC/AT. \$149.

InfoCode, Inc., 19 Union Square W, New York, NY 10003; 212/741-9411

CIRCLE 326 ON READER SERVICE CARD

Gateway Communications, Inc. has announced the **G/SNA Series**, a family of micro-to-micro and micro-to-mainframe communications links for PCs. **G/SNApc 3270** allows the PC to access an SNA host by emulating an IBM 3274 controller equipped with a 3278/9 terminal and a 3286/7 printer. **G/SNApc 3770** emulates an IBM 3770 RJE workstation for mainframe access. **G/SNA PCcom** allows direct PC-to-PC communication without requiring mainframe resources. **G/SNApc Combo** provides both 3270 and 3770 micro-to-mainframe communications. **G/BSCpc 3270** allows a PC to access a mainframe by emulating an IBM 3274 controller equipped with a 3278 terminal in a binary-synchronous environment. G/SNApc 3270, \$585; G/SNApc 3770, \$585; G/SNA PCcom, \$475; G/SNApc Combo \$795, G/BSCpc \$475. An API module, \$285, can be added to any of the above products except PCcom to provide a programmable interface to the emulator.

Advanced NetWare/G is a new network operating system for Gateway's G/NET LAN. It is compatible with Microsoft's MS-Net and IBM's PC Network with PC-DOS 3.1, and offers multiple file server support. Advanced NetWare/G provides multi-user capabilities, resource sharing, and extended performance; its system security features are both complete and flexible. \$1,595; upgrades from NetWare/G, \$295. *Gateway Communications, Inc., 16782 Red Hill Avenue, Irvine, CA 92714; 714/261-0762*

CIRCLE 327 ON READER SERVICE CARD

NEW FROM BORLAND

Borland Introduces Reflex, The Greatest Analytical Tool Since The Couch

INTRODUCING REFLEX, THE ANALYST.

If you use Lotus 1-2-3™, dBASE® or PFS File™, you need Reflex™—because it's a totally new way to look at your data. It shows you patterns, relationships and interrelationships you didn't know were there, because they were hidden in data and numbers.

Reflex is the first database that separates the trees from the forest. The first database that understands that what you see depends on how you look at it.

The first database that probes relationships—then shows them to you in various graphic forms—scatter, line, bar, stacked bar and pie charts.

The first database to break the bonds of traditional DBMS (Data Base Management Systems) and give a dramatic visual turn to data analysis.

Reflex makes graphic leaps far beyond 1-2-3. With Reflex, when you look, you see.

HOW THE CRITICS REACT TO REFLEX

"The next generation of software has officially arrived."

Peter Norton, PC Week

"Reflex is one of the most powerful database programs on the market; its multiple views; interactive windows and graphics, great report writer, pull-down menus and cross tabulation make this one of the best programs we have seen in a long time...The program is easy to use and not intimidating to the novice...Reflex not only handles the usual database functions such as sorting and searching, but also "what-if" and statistical analysis...it can create interactive graphics with the graphics module. The separate report module is one of the best we've ever seen."

Marc Stern, InfoWorld

"What you see, then, is an interesting hybrid of a database and a spreadsheet that is ideal for analyzing tabular data."

Adam B. Green, InfoWorld

"More flexible than spreadsheets, this easy-to-use database analysis package presents information with visual clarity...Reflex is for you. The flexibility of switching between different views of the data lets you see relationships you may have previously overlooked...Without "what-if" analysis, key variables—such as cost of goods sold or travel expenses—may be out of hand but unnoticed. The type of analysis to uncover such a foible is awkward to do on a spreadsheet; yet, it may mean the difference between success and failure in a competitive situation."

Ira H. Krakow, Business Computer Systems

REFLEX OPENS MULTIPLE WINDOWS WITH NEW VIEWS AND GRAPHIC INSIGHTS.

You use Reflex's Form View to build your database; the List View lets you put data in tabular List form; the Graph View gives you instant interactive graphic representations; the CrossTab View gives you amazing "cross-referenced" pictures of the links and relationships hidden in your data. Report View allows you to import and export data to and from Reflex, 1-2-3, dBASE, PFS File and other applications and prints out information in the formats you want. In fact, Report View is probably the best 1-2-3 report generator you can buy today. It's also the cheapest—and you're getting all the other features free.

The commands for all five Views are consistent—so you're not stuck learning five different ways to get something done. And because Reflex uses advanced windowing techniques, you can see several views on the screen at the same time—without having to switch back and forth. You get the picture—and the pictures—all at once—if that's the way you want to look at things.

Modify a number and all your Views—List, Form and Graph—are immediately updated, on-screen. Changing a number changes the picture—which is mighty handy when you're analyzing (let's say) sales figures by salesperson; or you're in "What-if?" country asking yourself "What if we could add 2.5% in January sales?" "Show me."

"Give me the picture." "Show me what happens when we shift 11% of Nebraska's inventory to the new store in Hawaii."

"Show me how many Gizmo 28's we have in every store in every state as of midnight last night and what happens to our East Coast stocks if the shipping strike lasts more than a week." "Show me."

So Reflex shows you. Instant answers. Instant pictures. Instant analysis. Instant understanding.

HOW IN THE WORLD CAN BORLAND SELL A PHENOMENAL PRODUCT LIKE REFLEX FOR ONLY \$99.95?

At \$495.00, Analytica's original price, Reflex was a bargain. Acclaimed by critics and praised by users, Reflex also got our attention at Borland International. We were so impressed by Reflex that we bought the company!

To celebrate that, we're making business software history by offering Reflex—FOR A LIMITED TIME—for ONLY \$99.95! (Offer good through March 31, 1986).

That's \$395.05 off the original price—which is a pretty good return on your toll-free phone call.

We think Reflex should be an "automatic product," a "standard" that every PC owner should own. That's why we priced it at \$99.95. Naturally we've added our 60-day money-back guarantee and Borland's Reflex is not copy-protected.



BORLAND
INTERNATIONAL

4585 Scotts Valley Drive, Scotts Valley CA 95066
Phone (408) 438-8400 Telex 172373

CIRCLE NO. 251 ON READER SERVICE CARD

Trademarks: Reflex is a trademark of BORLAND/Analytica Inc. Lotus is a registered trademark and Lotus 1-2-3 is a trademark of Lotus Development Corporation. dBASE is a registered trademark of Ashton-Tate. PFS is a registered trademark and PFS File is a trademark of Software Publishing Corporation. IBM PC, XT, AT, PC-DOS and IBM Color Graphics Adapter are registered trademarks of International Business Machines Corporation. Hercules Monochrome Graphics Card is a trademark of Hercules Computer Technology.

REFLEX™ THE ANALYST™

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add \$10 per product ordered.

System requirements.
IBM® PC, XT, AT and
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minimum; IBM Color Graphics
Adapter®, Hercules Monochrome
Graphics Card™, or equivalent;
PC DOS® 2.0 or greater; Hard
disk and mouse optional.

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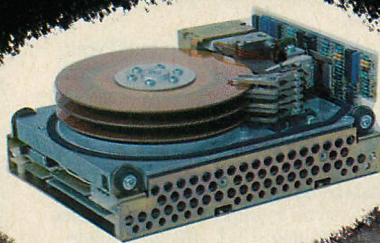
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COD's and Purchase Orders WILL NOT be accepted by Borland. California residents: add 6% sales tax.
Outside USA: add \$10 and make payment by bank draft, payable in US dollars drawn on a US bank.

Copyright 1985 Borland International BI-1020 A

"...Sherman tank of hard disk drives."

-InfoWorld
July 22, 1985



HAVE A NICE INQUISITION, DEAR.

When Infoworld's contributing editor, Bernie Zilbergeld and the InfoWorld Review Board said they reviewed our ATplus20™ hard disk drive, we figured that they gave it the routine technical and performance diagnostics.

We didn't expect *destructive* testing.

They went after our legendary resistance to head-crashes with a vengeance.

HOW TO HENCH.

Mr. Z and his henchpersons began by subjecting the drive to 3,500 stops and starts.

Having survived this, our ATplus20™ drive then had to face increasingly severe physical torture *while* performing a seemingly relentless series of track seeking operations.

THINGS THAT GO BUMP IN THE DAY.

Further henching resulted in their bumping the table that the ATplus20™ was running on.

Then they *dropped* one side of the table from a height of six inches.

Next, the entire table was lifted one foot above the floor and dropped.

After cutting power to the drive (thus interrupting the seek test) they bumped the table severely, to see if the ATplus20's unconditional and automatic park and lock feature really makes a difference.

Then, they threw the book at us.

Actually, they dropped a rather heavy book *directly* on top of the drive itself.

GUESS WHAT?

You're absolutely right. CORE's ATplus20™ hard disk drive not only survived, but continued to perform as specified.

Each of the rather unnerving tests was repeated a number of times on the same drive, just to be extra sure.

Or mean.

THE LAWYER'S 2¢.

The tests were so nasty that they had to publish the following warning:

"We caution you not to perform any of these tests on your own equipment."

We have to agree.

These tests were done to determine the limits of the drive, and were intentionally extreme beyond the normal use environment.

SEAL OF APPROVAL.

We're delighted that InfoWorld tested, evaluated and *validated*, exactly what we have been saying all along: *Now you can build the enhanced PC-AT that IBM didn't.*



DOS, XENIX & MORE.

Along with the highest *reliability* among PC-AT compatible drives, we offer *full compatibility* with PC-DOS 3.0 and higher.

And XENIX™ compatibility with CORE's ATplus™ XENIX update.

A significant number of ATplus drives are running under the IBM, NOVELL and other networks.

Those users are delighted with our speed and performance.

PEACE OF MIND.

ATplus™ drives come with a full one-year warranty, supported by CORE and other major maintenance service companies.

Thus, we offer you a choice of on-site, local, or exchange maintenance services.

Known as CORE's Sudden Support™, all services are extendable to your entire AT system, and after the warranty runs out.

WE'LL BE AROUND.

We're the world's largest supplier of high-performance PC-AT compatible hard disk drives.

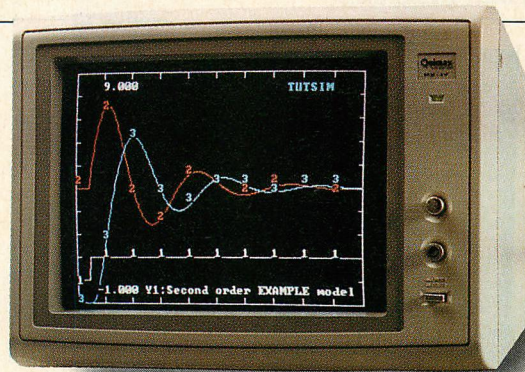
Now, respected magazines such as InfoWorld and PC Magazine have told you how we got there.

Please contact us directly for full and unedited reprints of this and other prominent computer magazine reviews.

7171 North Federal Highway Boca Raton, Florida 33431 305/997-6055
Telex: 315 809 CORE INTL DEBE



APL*PLUS UNIX System



TUTSIM high-resolution screen

Version 2.0 of the **REALIA, Inc.** COBOL compiler/debugger has been released. The compiler has received high-level certification: the update supports SORT/MERGE, improves indexed file efficiency, and adds a machine-level interface and other enhancements. Version 2.0 can sort 10,000 100-byte records in one minute. The REALIA SORT is a high-level implementation of the ANSI 74 SORT module with extensions from IBM VS COBOL and the ANSI 85 standard. \$995.

REALIA, Inc., 10 S. Riverside Plaza, Chicago, IL 60606; 312/346-0642

CIRCLE 324 ON READER SERVICE CARD

A new edition of **Utah COBOL** has been announced by **Ellis Computing, Inc.** Utah COBOL can compile and execute 5,000 statements in a typical 128KB partition. The compiler, based upon the ANSI-74 standards, can compile at a rate up to 4,500 statements per minute on a PC/AT. It generates optimized in-line machine language so object runtime is very fast as well. \$39.95.

Ellis Computing, Inc., 3917 Noriega Street, San Francisco, CA 94122; 415/753-0186

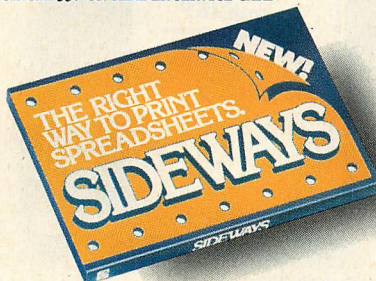
CIRCLE 325 ON READER SERVICE CARD

TUTSIM, the dynamic simulation program for modeling continuous systems on the microcomputer from **Applied i**, now has the added capability of producing high resolution graphic output in addition to medium output. TUTSIM can display four outputs from four blocks. Using the function keys, the user can cause the minimum and maximum scale for any of these four outputs to be displayed, along with an identification label consisting of any comment for that output block from the TUTSIM model listing. Short form (15 blocks), \$39.95; collegiate version (27 blocks), \$109.95; professional program (999 blocks), \$495. *Applied i, 200 California Avenue, Palo Alto, CA 94306; 415/325-4800*

CIRCLE 331 ON READER SERVICE CARD

Funk Software, Inc. has announced a new version of its **Sideways** printing utility. New features include the ability to read the Lotus 1-2-3 worksheet file format directly, to operate as a Symphony add-in application, and to print bold, underlined, and expanded type. It also supports a large base of dot-matrix printers. \$69.95; upgrade, \$20. *Funk Software, Inc., 222 Third Street, Cambridge, MA 02142; 617/497-6339*

CIRCLE 337 ON READER SERVICE CARD



By Funk Software, Inc.

Software Research Corporation introduced **SNE File Transfer Facility** (SNE/FTF), a network software package that enables the IBM PC (and compatibles) and Digital Equipment Corporation and WANG minicomputers to exchange information with each other or with MVS-based IBM mainframes. The capabilities include conducting multiple concurrent file transfers within the same session, making file transfer requests on-line or via batch-provided utilities, storing and forwarding information through the computer network, transferring different file types, notifying users on the completion of requests, and sending, receiving, and storing messages. SNE/FTF is packaged and priced modularly. Initial license fee: \$17,500 per host, \$5,000 per minicomputer, and \$400 per personal computer.

Software Research Corporation, One Natick Executive Park, Natick, MA 01760; 617/655-1133

CIRCLE 341 ON READER SERVICE CARD

STSC, Inc. has announced **APL*PLUS UNIX System**, an enhanced APL interpreter and applications development system for the PC/AT running under XENIX. It features partial compilation of APL code, multiple function and variable full-screen editing, concurrent file sharing, external process interface, nested arrays compatible with IBM's APL2, and a flexible communications facility that enables users to log onto a remote host computer and transfer data. \$995.

STSC, Inc., 2115 E. Jefferson Street, Rockville, MD 20852; 800/592-0050; in Maryland, 301/984-5123

CIRCLE 329 ON READER SERVICE CARD

Microsoft Corporation has announced a XENIX version of its **COBOL 2.1** and **COBOL Tools** for the MS-DOS and XENIX operating systems. COBOL Tools is a set of utilities for use with the Microsoft COBOL 2.1; it includes a powerful interactive symbolic debugger, an advanced cross-reference utility, a menu handler, and for MS-DOS, an easy-to-use mouse-input module. The XENIX and MS-DOS versions of Microsoft COBOL are source-code compatible, allowing developers to port their applications between the two operating systems. COBOL compiler 2.1, \$700; update from 2.0 to 2.1, \$50 (earlier versions, \$150); COBOL Tools, \$350; XENIX COBOL, \$950; XENIX COBOL Tools, \$450.

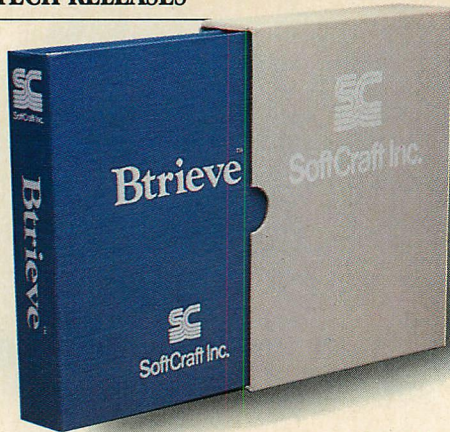
Microsoft Corporation, 10700 Northup Way, Box 97200, Bellevue, WA 98009; 206/828-8080

CIRCLE 323 ON READER SERVICE CARD

A software solution for the small scale (up to four nodes) LAN is being marketed by **IDEAssociates, Inc.** Called **IDEAshare**, the software package runs under PC-DOS linking four PCs, XTs, ATs, Portable PCs, or PCjr's to share hard disks, printers, and data. \$325.

IDEAssociates, Inc., 35 Dunham Road, Billerica, MA 01821; 617/663-6878

CIRCLE 335 ON READER SERVICE CARD



Btrieve for XENIX



By Fox Research, Inc.

A version of the **Btrieve** file management system for Microsoft Corporation's XENIX operating system has been announced by **SoftCraft, Inc.** To ensure data integrity in this multi-user environment, the XENIX version of Btrieve has record locking capabilities and coordinates access to the database to control simultaneous updates of records and provides automatic file recovery after a system crash. Based on the b-tree file indexing system, Btrieve allows as many as 24 keys per file and a maximum file size of more than 4 billion bytes. Btrieve can be used for applications development in BASIC, Pascal, COBOL, C FORTRAN and APL. \$595. *SoftCraft, Inc., P.O. Box 9802, Number 917, Austin, TX 78766; 512/346-8380*

CIRCLE 332 ON READER SERVICE CARD

Lotus Development Corporation has begun shipping **release 2** of its 1-2-3 analytic software and a new companion product, **1-2-3 Report Writer**. 1-2-3 now addresses up to 4MB of RAM when used with a memory board designed to the Lotus/Intel/Microsoft specification and supports the Intel 8087 and 80287 coprocessors. The worksheet has been expanded to 256 columns by 8,192 rows. 1-2-3 Report Writer allows 1-2-3 to generate business documents including invoices, personnel reports, sales analyses, and mailing labels from 1-2-3 files. 1-2-3 release 2, \$495; upgrade, \$150; 1-2-3 Report Writer, \$150. *Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, MA 02142; 617/577-8500*

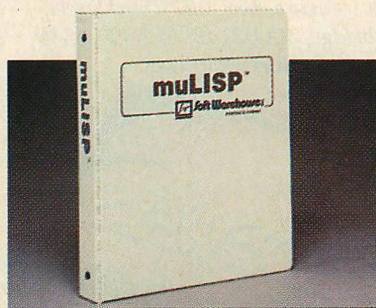
CIRCLE 338 ON READER SERVICE CARD

Soft Warehouse, Inc. has released **muLISP-85**, a new version of its fully integrated, window-based LISP programming environment designed for the development of sophisticated AI systems. It features 260 primitives, use of up to 512KB, exact and approximate rational arithmetic as well as integer arithmetic,

user-definable macros and functions, an upcoming native code compiler and pseudo-code compiler, and the power of Common LISP in a high-performance, compact form. \$250.

Soft Warehouse, Inc., P.O. Box 11174, Honolulu, HI 96828-0174; 808/734-5801

CIRCLE 333 ON READER SERVICE CARD



muLISP-85, an update

Two products that increase its connectivity in the LAN arena have been announced by **Fox Research, Inc.** The **10-Net RS-232 Node-to-Net Gateway** allows remote PCs to dial-in and become part of an existing 10-NET LAN System, providing the remote node all the functionality of the other nodes on the 10-NET LAN. This enables the remote PC to share all resources, data, and communications abilities enjoyed by all of the other nodes on the LAN. The **10NET RS-232 Net-to-Net Gateway** supports the joining of two or more 10-NET LAN clusters through the RS-232 link. This product also allows the sharing of resources and data communications abilities over telephone lines; it is able to connect one 10-NET LAN to another. Both gateways consist of software that works through a telephone and an asynchronous modem. Single PC link, \$89.95; multiple LAN version, \$295. *Fox Research, Inc., 7005 Corporate Way, Dayton, OH 45459; 513/433-2238*

CIRCLE 330 ON READER SERVICE CARD

A new implementation of LISP for the PC has been announced by **Northwest Computer Algorithms**. The kernel of the **UO-LISP 3.0** interpreter contains more than 200 standard LISP functions. Precompiled library packages expand the system to more than 400 functions. The interpreter is full RAM addressable; all functions are redefinable. Map functions, property lists, vectors, read and print macros, automatic garbage collection, operating system access, and I/O support are standard. **LEARN LISP SYSTEM** is a user-friendly subset of the full system. UO-LISP 3.0, \$150; subset, \$85. *Northwest Computer Algorithms, P.O. Box 90995, Long Beach, CA 90809; 213/426-1893*

CIRCLE 334 ON READER SERVICE CARD

Sigma Designs, Inc. has announced a driver that enables Autodesk's **AutoCAD** to run in high-resolution mode on its **Color 400** graphics card. The driver is part of AutoCAD's software package beginning with version 2.17F for the IBM series; it brings together the graphics tools needed by engineers, such as three-dimensional visualization, curve fitting, and macro programming. The program generates monochrome and color mechanical, architectural, and electrical drawings, schematics and flowcharts, and technical illustrations. Color 400 offers a (640-by-400) noninterlaced, high-resolution display, without flicker, and a palette of 16 colors; it supports a broad range of software products. AutoCAD, \$1,000. Color 400, \$695. *Sigma Designs, Inc., 2023 O'Toole Avenue, San Jose, CA 95131; 408/943-9480*

CIRCLE 299 ON READER SERVICE CARD

Autodesk, Inc., 2320 Marinesship Way, Sausalito, CA 94965; 415/331-0356

CIRCLE 298 ON READER SERVICE CARD

The material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the PC Tech Journal editorial staff.



Manx Aztec C86 is the best C for MS-DOS and you can prove it yourself!

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Aztec C86-c Commercial System	\$499
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Manx Cross Development Systems

Manx Aztec C compilers are available as native or as cross development systems for PC-DOS, MS-DOS, Macintosh, CP/M-86, CP/M-80, TRSDOS, Apple II, and Commodore 64/128.

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HOSTS: VAX UNIX (\$3000), PDP-11 UNIX (\$2000), MS-DOS (\$750), CP/M (\$750), Macintosh (\$750), CP/M-68k (\$750), XENIX (\$750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x85 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

Additional TARGETS are \$300 to \$500 (non VAX) or \$1000 (VAX). Call for information, on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

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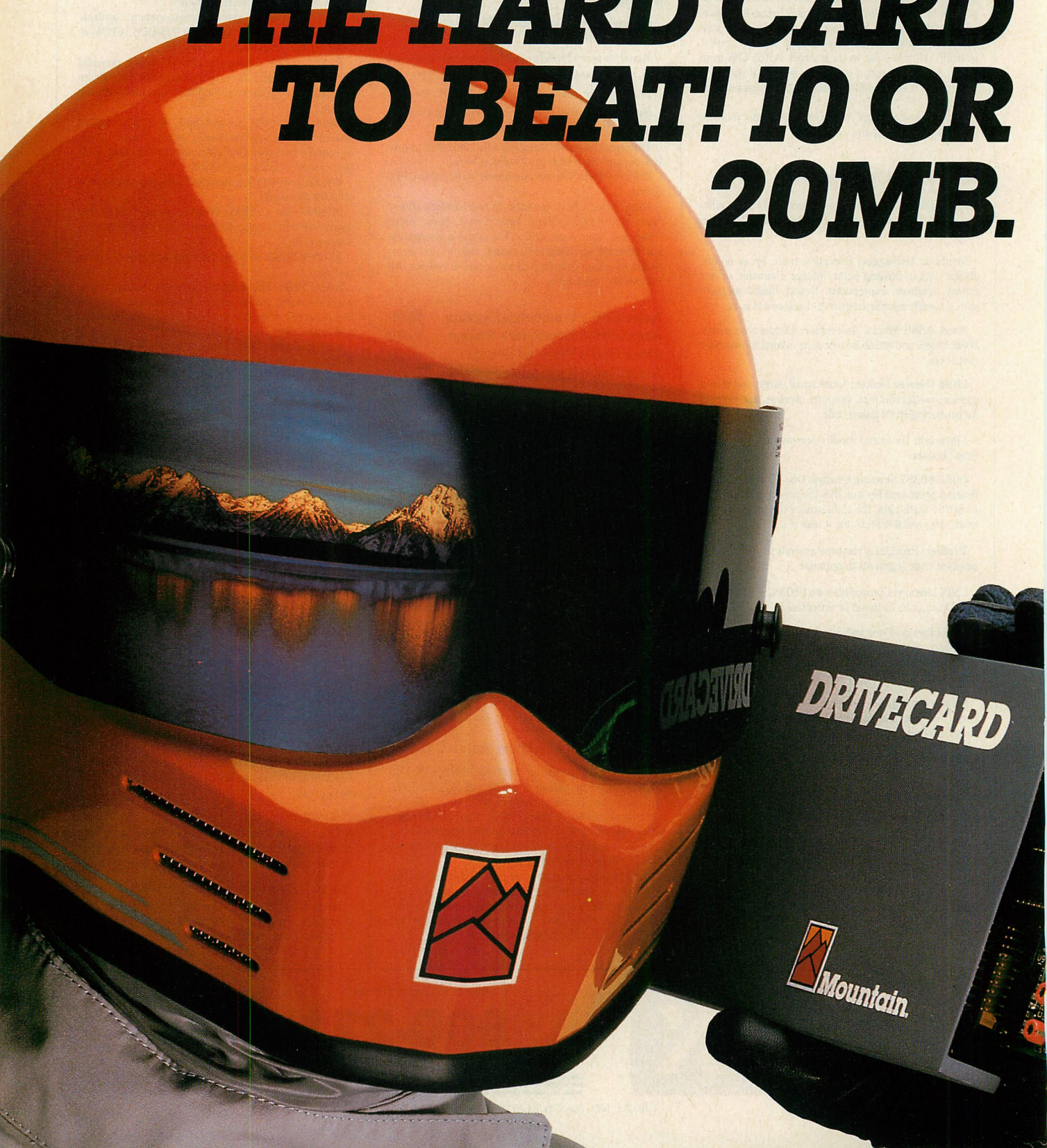
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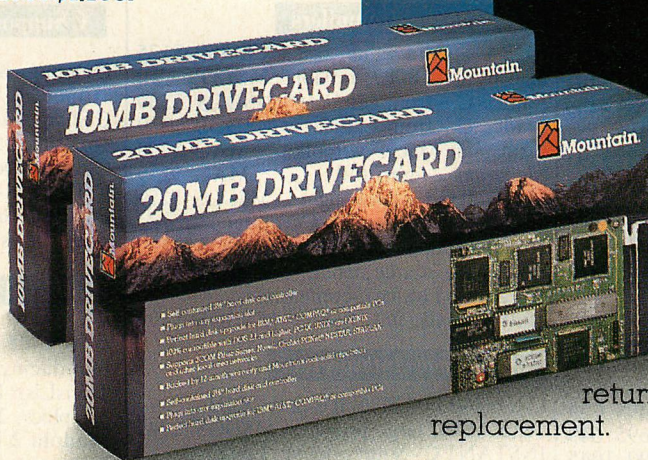
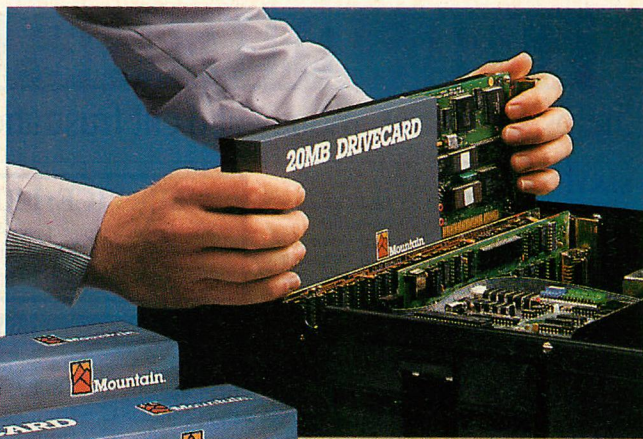
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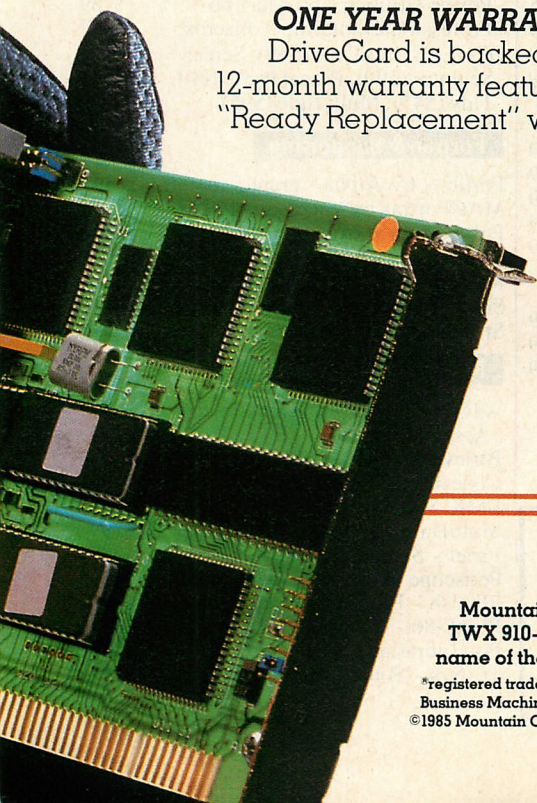
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VDISK on Command

A Turbo Pascal program allows the user to call up a RAM disk at any time during system operations.

RAM disks implemented by device drivers (such as IBM's RVDISK) have several advantages over those implemented as resident programs (such as AST's SUPERDRV). The latter must reproduce faithfully in memory the format of a physical disk, including two copies of a full-sized File Allocation Table (FAT), 2½ or 3½KB segments of directory, and space allocation units of 1KB each. Device drivers, on the other hand, can establish nonstandard disk formats with a single smaller FAT, shorter directories, and smaller allocation units, to make better use of the space available in memory.

Device drivers can be invoked through CONFIG.SYS only, but not by a command typed at the DOS prompt. The system reset cannot be avoided; however, it, as well as the editing of the CONFIG.SYS file, can be automated with the help of the Turbo Pascal program listed below. VDISK.PAS allows the installation and removal of the VDISK.SYS device driver on command.

Before using this command, a file called CONFIG.NVD (.NVD for No VDISK) should be created with the same contents as CONFIG.SYS except for the lines that install VDISK. In some cases, where VDISK is not normally installed when the system is first booted, CONFIG.NVD and CONFIG.SYS will be identical. VDISK.PAS assumes the system will be booted from the C: drive. If necessary, the program's two ASSIGN statements can be instructed to use another drive.

To install the RAM disk, the user types VDISK followed by parameters specifying the size and other characteristics of the RAM drive (see the "Configuring Your System" chapter in the DOS 3.x manual for help with this). If a RAM disk is already installed, this step will install an additional disk that will be designated by the next drive letter. An important point to remember, however, is that each execution of the VDISK command causes a system reset and will destroy the contents of previously installed RAM disks, print spoolers, and any other memory-resident data and programs.

LISTING: VDISK.PAS

Program VDISK;

var

ConfigSys, ConfigOld: text;
i, nparms: integer;
line: string[128];

begin

```
assign(ConfigSys, 'c:\config.sys');
nparms := ParamCount;
if nparms = 0 then {any command line parms?}
begin
  {no: copy file w/o vdisk to config.sys}
  assign(ConfigOld, 'c:\config.nvd');
  rewrite(ConfigSys);
  reset(ConfigOld);
  while not EOF(ConfigOld) do
```

Typing VDISK without any parameters uninstalls all RAM disks. Therefore, the default configuration (64KB, 128-byte sectors, 64 directory entries) always should be specified by at least one parameter.

The VDISK.PAS program tests for the presence of any command-line parameters and performs one of two functions depending upon the outcome of that test. If command-line parameters are present, VDISK.PAS opens the CONFIG.SYS file and appends to it a line consisting of the text **device=vdisk.sys** and the parameters from the command line. If, on the other hand, no parameters are found, the program copies CONFIG.NVD into CONFIG.SYS. As a result, all of the lines that install VDISK are removed.

The BIOS reset procedure (initiated by branching to absolute address FFFF:0) is performed both when the system is turned on and by an Alt-Ctrl-Del reset. The keyboard reset, however, posts a flag of 1234H in location 40:72 before branching. This value signals the reset procedure to skip the time-consuming memory testing that is performed at power-up. VDISK.PAS also posts this flag before branching, thus allowing for the shorter reset sequence. The flag is inserted into the absolute location by Turbo Pascal's equivalent of a BASIC POKE; it is assigned to the predefined MemW array.

Note that after using the VDISK command, the next keyboard reset or power-on will configure the system according to the latest contents of CONFIG.SYS. If VDISK normally is excluded from a system's configuration, the user might need to insert a command into the AUTOEXEC file that will copy CONFIG.NVD to CONFIG.SYS. It is important to note that by the time AUTOEXEC gets to this command, CONFIG.SYS will already have been processed.



Ted Mirecki has a master's degree in computer science and 20 years of experience in information processing. He is a corporate planner and is responsible for developing decision support systems.

```
begin
  Readln(ConfigOld, line);
  Writeln(ConfigSys, line);
end;
end
else begin {append 'device=vdisk...' to config.sys}
  append(ConfigSys);
  write(ConfigSys, 'device=vdisk.sys');
  for i := 1 to nparms do
    write(ConfigSys, ' '+ParamStr(i));
  writeln(ConfigSys);
end;
close(ConfigSys);
MemW[$40:$72] := $1234; {set warm boot flag in BIOS data seg}
inline($EA:0/0/$FFFF); {JMP FFFF:0000 to reset system}
end.
```

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Command Line Redirection

A program executed by IBM's Professional Debug Facility shows how COMMAND.COM redirects devices and files through file handles.

To see how COMMAND.COM handles command line redirection, a simple program called BRK.EXE can be executed using IBM's Professional Debug Facility (RDT). The assembly language for BRK.EXE is as follows:

```
PUSH DS, ;place INT 20H
XOR AX,AX ;address on stack for return
PUH AX   ;
INT 3    ;enter RDT
RET      ;terminate program
```

After the break, the window facility of RDT displays the Program Segment Prefix and DOS's list of open file handles.

Each file handle returned by the DOS open function (3DH) is a 16-bit word in the range 0000H to 0013H. DOS allows each process a maximum of 20 active file handles at one time. Five of them have default assignments:

```
standard input device = 0000
standard output device = 0001
standard error device = 0002
standard aux device = 0003
standard prn device = 0004
```

For an IBM PC, these file handles initially map into the physical devices, CON, AUX, and PRN; the CON device uses handles 0000 to 0002. A single device or file can be mapped into multiple file handles using the DUP function 45H.

DOS keeps an internal sequential list of devices and files opened using function 3DH. The list is a series of data structures, one for each file or device. DOS allocates space for eight entries by default, but this can be changed by the FILES= command in CONFIG.SYS. For files, an entry is made up of directory information; for devices, the entry contains the device header pointer and attribute information. Because one entry in this list may map into several file handles, an additional data structure is needed to define the mapping. This structure is an array at offset 18H in the Program Segment Prefix. The value of the element in the array is the file handle, and the sequence of the elements is the order that DOS opened the files or devices. File handle numbering starts at 0; a value of FFH indicates an unused file handle.

If BRK.EXE is executed using the command **brk**, the file handle in the Program Segment Prefix will look like the following when the break occurs

```
01 01 01 00 02 FF FF FF FF ..... FF
```

and the list of open devices and files will be AUX, CON, PRN. This shows that AUX, the first device that was opened by DOS, has been assigned file handle 0003.

If BRK.EXE is executed with redirection using the command **brk <CC.BAT>>TEST**, DOS opens the files CC.BAT

and TEST and assigns to them file handles 0005 and 0006, so that the Program Segment Prefix looks like this:

```
01 01 01 00 02 03 04 FF FF FF FF ..... FF
```

The input file (CC.BAT) handle is 0005 and the output file (TEST) handle is 0006 with corresponding list entries 03 and 04. Then, the redirection is done by mapping file handles 0000 and 0001 into entries 03 and 04, freeing up file handles 0005 and 0006. Thus, the corresponding elements are set to FFH, and the Program Segment Prefix becomes

```
03 04 01 00 02 FF FF FF FF ..... FF
```

which corresponds to the following open devices and files: AUX, CON, PRN, CC.BAT, TEST. This is the form of the Program Segment Prefix at the break point.

Standard input is obtained from the file CC.BAT, and the standard output is sent to the file TEST, by mapping file handles 0000 and 0001 to the corresponding files.

The redirection to TEST is an append operation, so COMMAND.COM not only opens TEST, but it also performs a file seek to the end of the file. This is accomplished using DOS function 42H with subfunction 02H and CX=DX=0. The IOCTL function allows the user to switch devices between raw, or binary, mode and ASCII mode so that ^Z is either passed or filtered when a device is read. A similar toggle is not available for files, so that the file seek treats the file as binary without any detection of ^Z. Thus, for a WordStar file, which pads the last 128-byte block of the file with ^Zs, any number of end-of-file marks may precede the append point. For that matter, if a single ^Z is the last character of the file, the appended data will start at the next byte.

File pointer seeks cannot be done in binary and ASCII modes. A method of looking through a file in ASCII that searches for ^Zs would need to look for the first end-of-file mark or the last byte file, whichever comes first. The routine that does the file seek is in the transient portion of COMMAND.COM. Patching it to high memory after it is relocated requires changing the transient checksum routine in the resident portion of COMMAND.COM, which is not desirable.

An alternative is to use the ASCII mode feature of the CON device by doing a redirected type with the batch file:

```
type %1 >temp
del %1
ren temp %1
```

Eliminating the ^Zs from file would allow the append operation to work as intended.



Stan Mitchell is a software engineer at Sysgen, Inc. in Fremont, California. He has a master's degree in geology.

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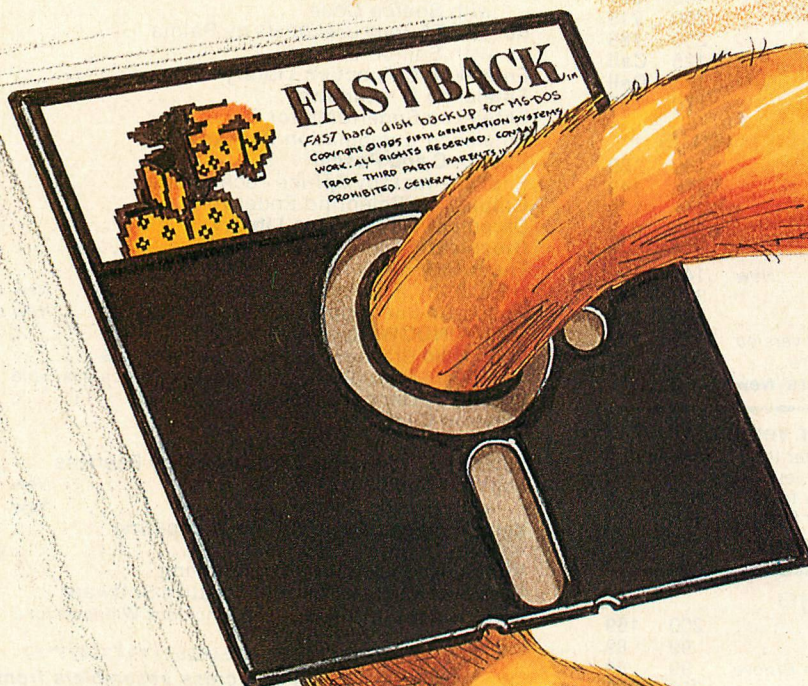
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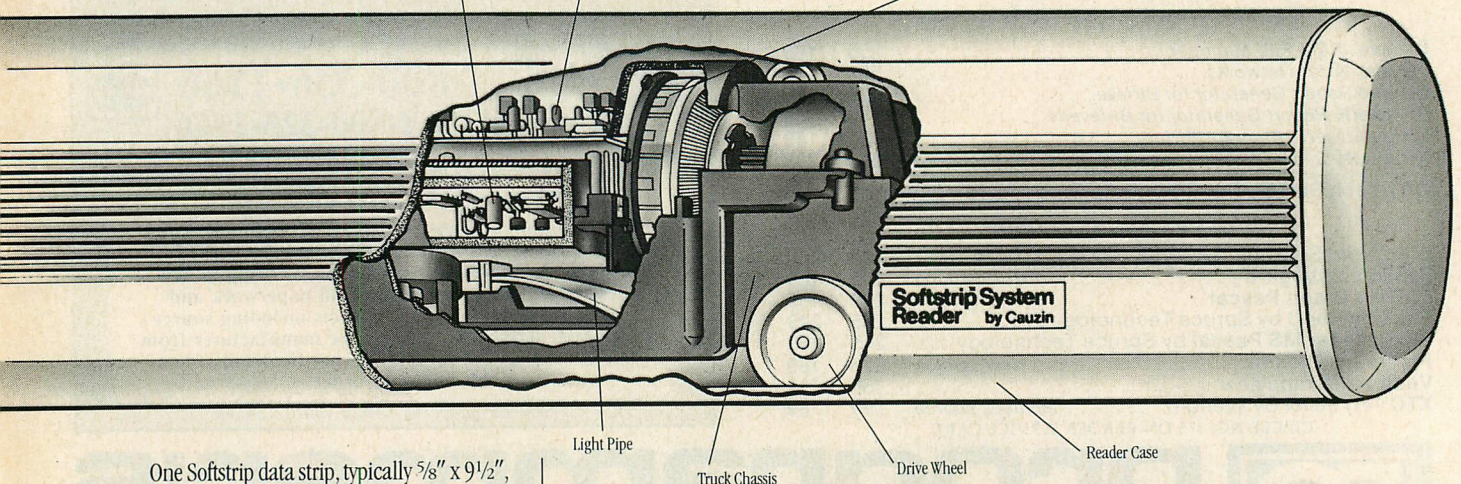
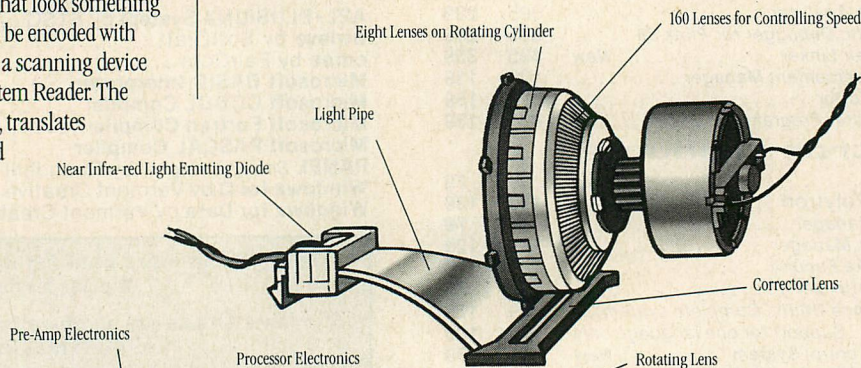
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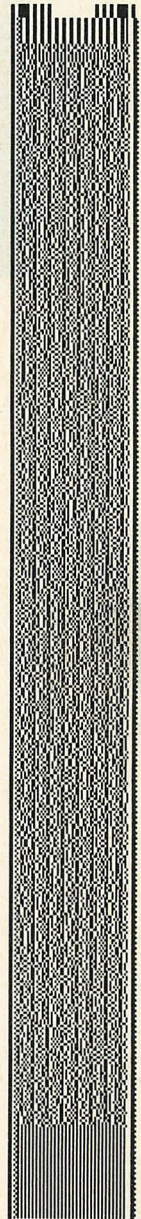
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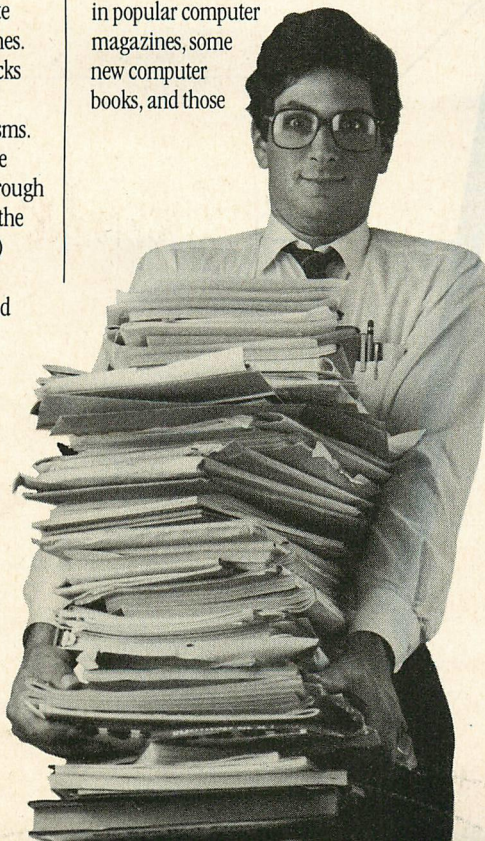
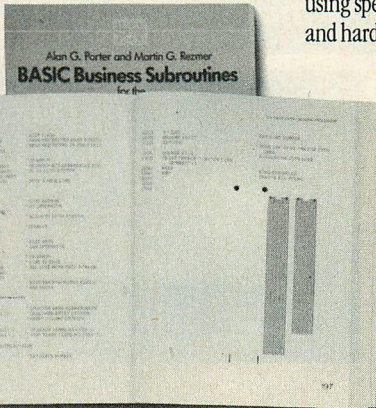
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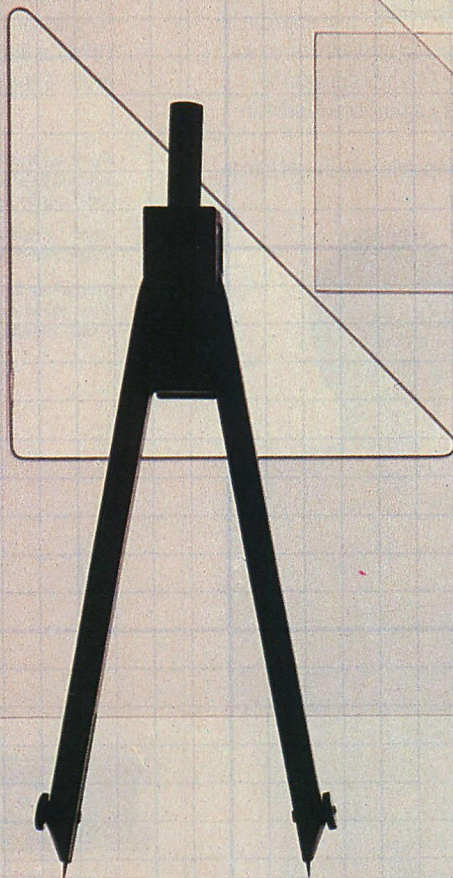
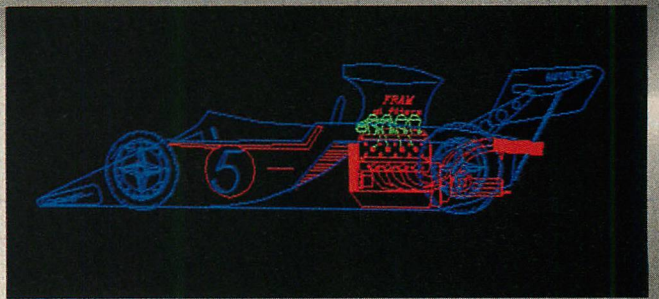
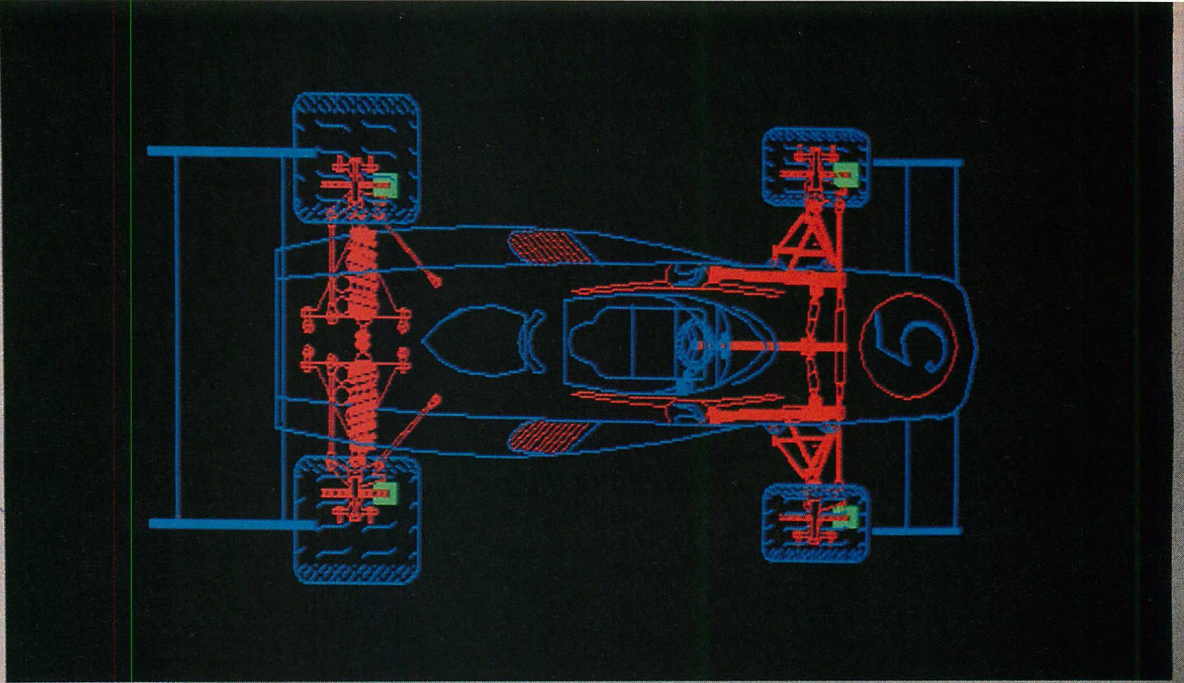


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While not necessarily the first program of its kind, AutoCAD 2.1 seems to have captured an impressive lead in the number of computer-aided drafting (CAD) systems installed—more than 30,000 AutoCAD packages have been sold, and shipments run about 2,500 per month. A number of competitive products are available—CADVANCE, VersaCAD, CADKEY, DRAPHIX II, just to name a few. However, the combined sales of these products do not equal those of AutoCAD.

Autodesk Inc.'s AutoCAD 2.1 is designed to run on a variety of 16-bit microcomputers and to produce drawings that would normally be drawn on a drafting board. Version 2.1 represents a significant improvement over earlier versions of AutoCAD and over other microcomputer CAD programs. The original AutoCAD and its revisions through 1.4 are suitable for creating and plotting

drawings, but not in a production environment. Options are available to enhance the program's capabilities, but it is strictly a drafting program.

AutoCAD 2.1 incorporates many features found in larger CAD systems. AutoCAD 2.0, introduced in the fall of 1984, began to demonstrate the potential of becoming a true computer-aided drafting and design (CADD) program, and AutoCAD 2.1 is a further refinement. The basic product, as shipped from Autodesk, is still a generic drafting package, but one with well-documented design extension facilities.

Upgrading to 2.1 from 2.0 requires very little effort. The enhancements seem to be logical extensions of the original AutoCAD program. Many of the enhancements are based on requests from users, who are primarily designers and who admit no limit to their microcomputer-based CAD systems.

PHOTOGRAPH BY JAY BRENNER

Drafting by Design

AutoCAD 2.1, the top-selling computer-aided drafting package for microcomputers, offers many of the design extensions of a larger CADD system.

VICTOR E. WRIGHT

These users provide constant feedback in the form of suggestions for new and more powerful features.

CAD/CADD DIFFERENCES

A CAD program allows the user to create, edit, display, store, retrieve, and plot drawings on a computer. It replaces a number of drafting tools, media, and storage facilities. Drawings are created by entering primitive drawing elements (such as lines, circles, points, arcs, and text) with an input device, that are both displayed on the computer's screen and stored on disk.

A CAD developer creates a drawing using either primitive drawing elements or his own abstract symbols derived from primitive drawing elements. Design calculations, analysis, and synthesis require other techniques.

A CADD system, on the other hand, performs many parts of the design process automatically, reducing the need for independent design tools. It includes a CAD program or a collection of CAD programs (AutoCAD can be the CAD facility at the heart of a micro-based CADD system), along with various other programs that automate design tasks. A designer using a CADD system, therefore, can deal in more abstract terms than can a CAD user.

AutoCAD 2.1 is a two-dimensional, drafting-only program, suitable for the creation of plane drawings. AutoCAD can be used to create traditional three-view drawings, supplemented with auxiliary (true) views; the drawings, however, are still two-dimensional.

AutoCAD 2.1 does add a limited third dimension to drawing objects. In addition to the *X* and *Y* coordinates that determine an object's position in the *X-Y* plane, objects in an AutoCAD drawing have a *Z*-axis coordinate, or elevation above the *X-Y* plane. The drawing can be viewed from any point in the drawing universe, which produces the effect of isometric or axonometric drawings. Drawing objects can be plane figures or extrusions of plane figures—assigning a thickness to a line creates a plane parallel to the *Z*-axis, and an extruded circle is a cylinder. The system, however, does not provide the ability to draw lines or plane figures inclined to all three axes and does not include three-dimensional objects—cubes, spheres, domes—in its catalog of primitive drawing objects. AutoCAD 2.1 seems at least to lay the foundation for true three-dimensional capability by including hidden line removal and other essential ingredients.

In contrast, large systems are usually true three-dimensional systems.

Drawing objects are entered with coordinates in three dimensions. The program can extract an arbitrary number of two-dimensional views of an object or drawing. Actually, the three-dimensional system stores an electronic model of an object or collection of objects, and the views are projections of the model on a viewing plane. The few three-dimensional CAD programs available for microcomputers mostly are conceptual modeling tools, not production drafting tools, as is AutoCAD 2.1.

HARDWARE NECESSITIES

Twelve different 16-bit microcomputers (counting the IBM PC family and all 100-percent compatible machines as one) can be used to run AutoCAD. Performance varies among machines: the program runs somewhat faster on a PC/AT than on a PC/XT or PC, but the real speed increase apparently is realized on 8-mHz 80286 machines, such as the

AutoCAD 2.1 can be used to create traditional three-view drawings; however, the drawings are still only two-dimensional.

Compaq 286. Autodesk supplies a list of all the hardware configurations that are supported by AutoCAD.

A computer suitably equipped to run AutoCAD should have 512KB of RAM, the 8087/287 math coprocessor, and a hard disk. Drawing regeneration on a minimal system—384KB of RAM and two floppy disks—can be painfully slow on complex drawings. A hard disk is probably the most important addition to the minimum configuration. AutoCAD is a large program that uses overlays, and thus must refer to the disk quite often. In addition, it uses the disk as virtual memory, so the speed of disk access is most important.

An 8087/287 chip helps to speed up AutoCAD's arithmetic, which affects the time it takes to draw (or redraw) circles, arcs, and text. AutoCAD claims that the addition of the 8087/287 increases speed by 300 percent or more.

AutoCAD features modular device drivers. Among the supported devices are several pointing devices (mice, digitizers, trackballs, joysticks, and light pens), which are recommended in or-

der to achieve the greatest level of efficiency when working with AutoCAD.

The program also supports a variety of plotters, ranging from the A-size Houston Instrument plotters to the E-size Calcomp and Hewlett-Packard plotters. Beginning with version 2.1, AutoCAD supports not only pen plotters, but also printer plotters, which are raster-type devices. Printer plotters are graphics printers—the Datacopy Model 90 Integrated Imaging System, the Epson FX-80, RX-80, or RX-100, the Hewlett-Packard Laserjet 2686A, and the Okidata 84 and 93—and do not provide the resolution of the pen plotters, but they can produce check plots quickly. Although printer plots are not comparable in quality to pen plots, the support of raster devices may indicate support of large raster-type plotters—electrostatic plotters—in the future.

Connecting plotters and pointing devices is not always a trivial matter, especially to the IBM PC. The AutoCAD manual includes wiring diagrams for cables where special cables are required, as well as for switch settings. Although the manual does not mention it, many devices can be attached with the use of Smart Cable instead of custom cables. Also, devices that are not supported by AutoCAD sometimes can be connected by configuring the device to emulate a supported device and connecting it with the appropriate cable.

The choice of a color/graphics adapter and monitor seems to affect the AutoCAD system's response and is especially important when using AutoCAD on the PC family and compatibles. Other computers, such as the Zenith Z-100, have excellent graphics in their standard configurations, and in many cases, AutoCAD supports only the standard configuration. The PC family, however, is supported in various display adapter configurations.

When working with the PC, a high-resolution color/graphics card and a long-phosphor color monitor are practical necessities. The PC's resolution of 640-by-200 pixels is too coarse for extended drawing sessions and is limited to use on monochrome displays only.

A graphics card with a moderate amount of screen memory, such as the IBM Color Graphics Adapter, produces smooth screen cursor movement on the PC, whereas an IBM Enhanced Graphics Adapter stuffed with 256KB of RAM produces jerky screen cursor movement on the same machine. However, the CGA is limited to use on a monochrome display in its low-resolution (by CAD standards), all-points-addressable mode.

The EGA produces a higher resolution—720 by 348—in 16 colors.

If high resolution is important, but color is not, the answer may be the Hercules Graphics Card. This card uses a moderate amount of screen memory—64KB—and produces smooth cursor movement at a resolution of 720-by-348 pixels. Monochrome monitors that are long-persistence do not produce screen flicker problems.

TWO MAIN PROGRAMS

AutoCAD 2.1 can be purchased in three configurations, ranging from a \$1,000 basic drawing program to a \$2,500 package that includes two Advanced Drafting Extensions overlays, ADE 2, and ADE 3. The price of the full package is out of the class of the casual user, but entirely feasible for the small business owner. A summary of the features that are contained in each package appears in table 1.

The full package is comprised of two main programs—the drawing editor and the plot program—and several utilities, all of which are selected for use from the main menu that appears as soon as AutoCAD has been loaded. The user also can invoke the plot program and several of the utilities while working within the drawing editor.

The drawing editor operates in a continuous loop. It prompts for a command, and when a command is entered, it prompts for the values of appropriate parameters and then executes the command. Finally, it returns to the top of the loop, prompting for another command. Pressing the return key or space bar repeats the previous command, which speeds repetitive tasks.

Under control of the drawing editor, AutoCAD 2.1 divides the screen into several areas as shown in photo 1. All prompts and user responses are displayed in a three-line text area at the bottom of the screen. The largest portion of the screen is dedicated to the graphics display area.

The third area, located on the right-hand side of the screen, is the screen menu. Commands can be entered by positioning the menu cursor to highlight a command and pressing either the Return key or the Space bar.

A single line of text at the top of the screen comprises the fourth area of the AutoCAD screen. This status line serves as a reminder of the settings of various modes and options. In the full version, it displays the coordinates of the screen cursor, providing a continuous read-out of the position of the cursor on the drawing.

TABLE 1: AutoCAD Features

BASIC AUTOCAD PACKAGE	
Absolute/Relative input	• Quadrant
Double precision floating point	• Intersection
Help command	• Insert
Drawing entities	• Perpendicular
Unlimited named layers	• Tangent
	• Nearest
Linetypes	Dynamic shape dragging
Text styles	Partial deletes
Zoom	Fillets
Move	Hatching
Erase	Sketch mode
Change	Unit specification
Arrays	• Engineering
Blocks	• Architectural (in feet and inches)
Nested blocks	Named views
Inserts	Rotated grid/snap/axis
Screen menu	Isometric planes
Tablet menus (4)	Slides capability
Custom menus and scripts	Attribute assignment
	Attribute editing
	Attribute extract
ADVANCED DRAFTING EXTENSIONS 2	
Dimensioning	• To databases
• Angular	• To spreadsheets
• Diameter	• To post-processors
• Radius	Mirroring
• Leaders	
• Center mark	ADVANCED DRAFTING EXTENSIONS 3
• Variables	Three-dimensional visualization
Length/Angle display	Polylines
Object snap	Freeze and thaw capabilities
• Endpoint	Hidden line
• Midpoint	Highlighting
• Node	Curve fitting

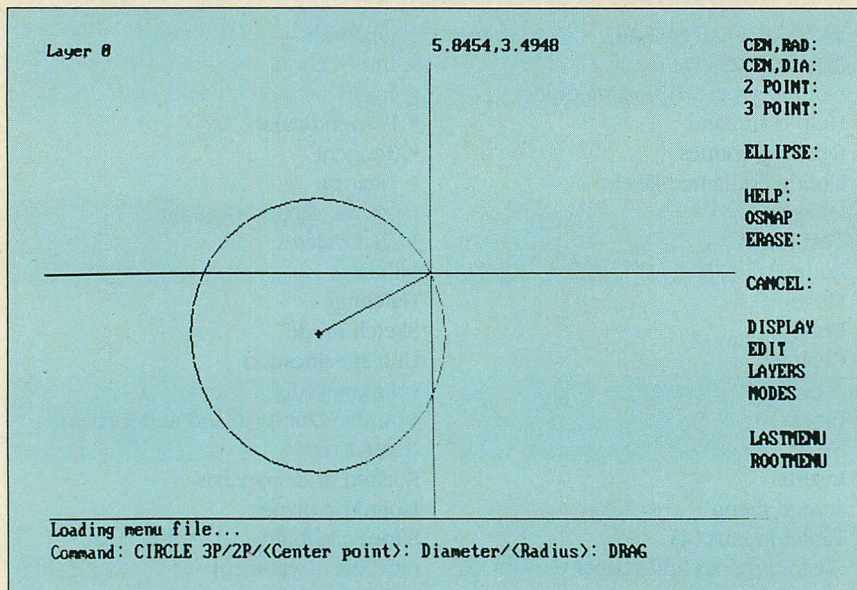
The basic AutoCAD package is available with two optional drafting extensions packages. The more significant features for each of the options are listed above.

The PC version of AutoCAD also provides for several dual screen configurations using two display adapters. This dual screen mode uses one screen for the display of text—command prompts, user responses, messages—and the other for the graphics display. It should not be confused with the dual screen display of a large system (Intergraph, for example) that can either show separate graphics views on two screens or use both screens for a larger display of a single view.

AutoCAD marks the position at which it is ready to accept data input with either the screen cursor or the menu cursor. The screen cursor is a set of cross-hairs that can be positioned on the screen to enter coordinate data in an interactive manner, and the menu cursor is a reverse video bar, such as that used in spreadsheet programs. Only one cursor is active at a time. If a pointing device is used, moving the de-

vice moves the cursor; attempting to move the screen cursor out of the graphics area causes it to disappear and the menu cursor to appear. If no pointing device is used, the active cursor is selected with function keys and positioned with the arrow keys.

A third cursor, the rubber band cursor, appears during the use of many of the drawing commands to provide a true preview of the entity being drawn. For example, when the command to draw a line segment is entered, the program prompts for the first endpoint. After the first point is selected, and as the cursor is moved to indicate the second endpoint, a line joins the first point and the cursor. This line, the rubber band cursor, previews the appearance of the line. The rubber band cursor operates in a similar manner for the commands that draw circles and arcs; it dynamically displays the radius or diameter of the shape as that shape is being drawn.

PHOTO 1: AutoCAD Screen

The screen is split into the command prompt area, the screen menu area, the status line at the top, and the graphics display area. The graphics display area pictured above shows the drag mode with the circle and the rubber band cursor.

AutoCAD 2.1 also features a drag mode with selected commands. This displays shapes dynamically while the cursor is defining their shape. For example, as the cursor is moved to indicate the radius of a circle, the circle is continuously erased and redrawn at the appropriate size, as shown in photo 1.

THREE TYPES OF MENUS

AutoCAD's menu system reduces the need to memorize commands or command syntax. Use of the menus is optional; commands can be entered directly from the keyboard without having to step through menus. Three types of menus are provided: screen menus, tablet menus, and auxiliary keyboard menus, all of which can be customized.

AutoCAD 2.1 introduced a command menu system that is considerably improved over previous versions. Earlier menu structure consisted of a simple, linear list of commands. The new screen menus are hierarchical, or tree-shaped. A menu selection can be a command executed directly or a command to display a submenu.

AutoCAD is not unique because it provides tree-shaped menus—a number of other CAD programs use the same concept. However, most of these other programs use a fixed menu that is built into the program; AutoCAD's menus, on the other hand, are stored in text files, which can be created and modified with both word processors and text editors. The manual includes a section that

explains the structure of menu files and presents examples of each of the three types of menus.

The program includes a default menu file, ACAD.MNU, which is loaded by the program if present on the default disk. The standard menu includes all the standard commands and options to commands. The program can be operated exclusively with the screen menu if desired. Screen menus can be changed at any time during a drawing session with the MENU command.

Custom menus can be created for digitizer tablets. A digitizer menu requires an overlay for the digitizer—a grid of boxes, each containing a command or command sequence that can be created and plotted with AutoCAD. As with the screen menus, menu overlays and the associated menu file can be changed during a drawing session.

The power of AutoCAD's menu system is not apparent at first, because the standard menu is a straightforward implementation of the standard command structure. However, the basic menu system provides the capability of defining a virtually unlimited set of macros, which can be called from any one of the menus. With the addition of the variables facility that is provided in ADE 3, the menu system becomes a fairly complete programming language that includes list and string handling, arithmetic and trigonometric functions, logical predicates and operators, and IF...THEN...ELSE...constructs, in addition

to graphics functions. The ability for one menu selection to call another menu becomes the equivalent of a subroutine or procedure call capability.

CREATING DRAWINGS

An AutoCAD drawing is created from primitive drawing elements, including points, lines, circles, arcs, solids, traces (wide lines), polylines (more wide lines), and lines of text. The commands to create these elements are entered by typing the name of the element or by selecting the command from a menu.

As drawing elements are entered, AutoCAD adds them to the drawing database stored in memory. Periodically, the program writes these elements to a disk file, thereby using the disk file both as permanent drawing storage and as virtual memory. A drawing session can be terminated at any time by entering the command END in response to the command prompt. END instructs AutoCAD to update the disk file and to return to the main menu.

Commands that create drawing elements typically require the elements to be completely defined. A line requires two endpoints, a circle requires a center and a radius, or three points, or a center and a diameter, etc. The user can enter these values either by typing them in from the keyboard or by using a pointing device to position the screen cursor at the desired locations.

Using AutoCAD in its basic configuration to create drawings is very similar to the manual drafting process. AutoCAD's terminology follows traditional drafting terminology where appropriate. However, the concept of the scale of the drawing differs. A person working at the drawing board must determine the scale of the drawing before beginning, by calculating the ratio of the size of the actual object to the size of the drawing. Objects are then drawn to that scale with the aid of templates and scale rulers. An AutoCAD drawing, on the other hand, is defined in real-world units. The scale of a drawing does not enter the picture until the drawing is plotted—with the exception of text, as will be explained in detail later. This concept of working in real units even though the display is scaled to fit on the computer's monitor is difficult for some draftsmen to grasp in the beginning.

AutoCAD provides commands to create seven basic drawing entities: lines, circles, arcs, traces, solids, lines of text, and points. Lines, circles, and arcs are drawn with single strokes on the plotter and displayed on the screen as a single pixel in width. Traces are wide

lines plotted with one or more pen strokes and displayed on the screen as lines of a specified width. The width of a trace is specified in drawing units. Solids are filled areas comprising three- or four-sided areas. Points are displayed either as a single dot on a plot or as a single pixel on the screen.

AutoCAD is oriented to production drafting. The LINE command allows rapid entry of strings of line segments. When the first line segment is entered, the program repeatedly prompts for the endpoint of the next segment, assuming that it will continue from the last point entered. In a similar manner, arcs can be continued from the end of the last line segment entered by pressing return instead of entering a new point, and lines can be continued from the endpoint of the last point of an arc.

The ADE 3 package adds polylines to the basic entities. A polyline is a single drawing entity consisting of a series of connected line segments and arcs. It is entered with the PLINE command and can be edited with the PEDIT command. A polyline can assume more properties than can a line, arc, or trace; it can be wide, tapered, drawn with dot/dash linetypes, chamfered, filleted, or transformed into smooth curves passing through the vertices or endpoints of the segments. Connected lines and arcs can be converted to polylines and then dressed up by converting them to varying widths or line weights.

Text is entered with the TEXT command, which prompts for alignment options, text height, rotation angle, and the text itself. The text facility provides for a variety of fonts and styles, which can be mixed in a single drawing. The standard package includes five fonts, each of which can be stretched, compressed, slanted, or mirrored with the style option of the TEXT command. Four alignment specifications are available—left justified, centered, right justified, and aligned (fitted between two points). The manual explains how to create additional fonts, and a number of custom font packages are available from third-party vendors.

AutoCAD provides for repetition of the text command in a manner that differs from repetition of other commands. When the TEXT command is repeated by pressing the return key or space bar, it prompts only for the new text, assuming the same justification, height, and rotation angle, and using a predetermined line spacing. Notes can be entered quickly this way.

Another AutoCAD drawing entity is the shape, which is a special symbol de-

fined from lines, arcs, and circles. AutoCAD includes sample shape files, and the manual explains the method for creating files of shapes. They are easy to use, but not to define. Although shapes are fast and efficient, complex objects are easier to create with the BLOCK facility described below. Shapes must be created and saved before use. Blocks can be defined on the fly but sacrifice speed and efficiency of storage. The custom fonts mentioned above are actually shape files.

DRAWING SIZE

An AutoCAD drawing is not limited in size by the amount of memory installed in the computer. Its limits are more

The concept of working in real units even though the display is scaled to fit on the computer's monitor is difficult for some draftsmen to grasp in the beginning.

likely to be set by disk capacity and operating system constraints. An AutoCAD drawing is a disk file that can be processed for screen display or for plotting on hard-copy media. During an AutoCAD session, a drawing exists in three forms: a backup file that is identical to the drawing file as it existed at the beginning of the session, temporary files reflecting the changes made during the session, and memory buffers containing changes not yet posted to disk. When a drawing session is ended, the program writes the contents of memory to the temporary disk file and renames that file to be the drawing file. If the memory buffer becomes full during a drawing session, AutoCAD writes the changes directly to disk.

Two aspects of drawing size must be considered. One relates to the number of drawing entities contained in the drawing file. AutoCAD stores drawing objects in vector form, not as a list of points, so a small circle takes the same amount of space in the drawing file as does a large circle. A drawing of a physically small object, but a complex one, may take up more disk space than a drawing of a large but simple object.

The second aspect of drawing size is the area represented by the drawing.

In AutoCAD's terms, the physical size of the drawing, or the drawing world, is set by the LIMITS command. The default size of an AutoCAD drawing is 12 units wide by 9 units high, displayed in decimal form. Setting the drawing limits does not prevent objects from extending outside the limits, although some objects cannot be completely created outside the limits. Drawing limits can be set from 10E-99 to 10E99 in both the X and Y dimensions, so for all practical purposes a drawing can be infinite.

However, the drawing size has practical limits. AutoCAD uses floating-point arithmetic for obvious reasons—16-bit integer arithmetic would limit drawing size. However, large systems use integer arithmetic for drawing coordinate data. The 32-bit integer arithmetic available on a VAX provides a three-dimensional drawing space that allows as many as 4 billion addressable points in each dimension.

In fact, the AutoCAD system allows for larger drawings than does the VAX-based Intergraph system, but the larger system has an advantage. A drawing database based on integer arithmetic has the same resolution over the entire design space; the distance between two addressable points at the limits of the space is precisely the same as the distance between two addressable points near the origin. A drawing database that is based on floating-point arithmetic has fine resolution close to the origin and coarser resolution as the distance from the origin increases. AutoCAD, however, provides more than adequate resolution for most drawings—ranging from integrated circuit layout to continental maps.

DISPLAY CONTROL

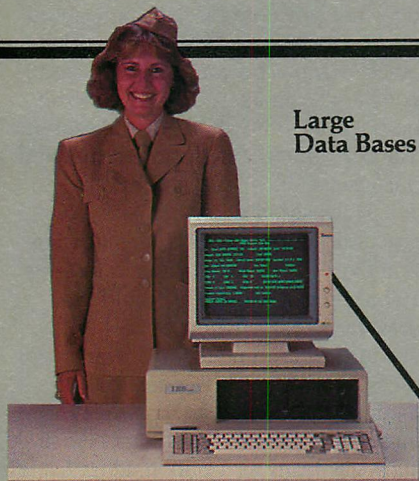
The CRT screen of most personal computers is considerably smaller than the drawing that will eventually be plotted, and the resolution is considerably lower than that which can be plotted. Discerning details when an entire drawing is displayed on the screen is virtually impossible. In most cases, only a small portion of the total drawing need be displayed at any given time, thereby allowing details to be displayed with a workable resolution. Thus, the display on the screen becomes a window, or viewport into a total drawing, just as a spreadsheet display is a window into a worksheet that is too large to display in full on the screen.

Most CAD programs for microcomputers allow changing the scale of the display to compensate for the lack of resolution—the usual command is

VERY LARGE MASS STORAGE

for one or more users

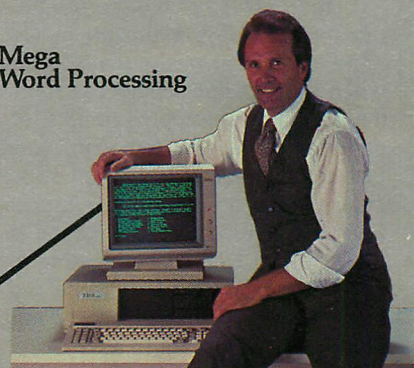
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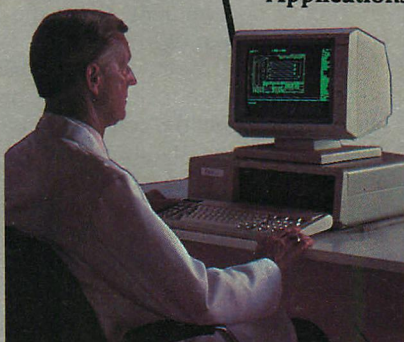
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ZOOM. Some programs allow the scale of the display to be changed in predetermined steps, and others continuously over a narrow range. AutoCAD provides a ZOOM range of a trillion to one. Presumably to demonstrate this capability, the AutoCAD package includes a scaled drawing of the solar system, including the orbit of Pluto and a detail of the 1969 lunar lander. The drawing can be ZOOMed so that the name of a single astronaut, inscribed in a plate on the lander, fills the entire screen.

The ZOOM command is typical of most AutoCAD commands in that it offers the user several options. ZOOM ALL displays the entire drawing; ZOOM EXTENTS displays the portion of the drawing that contains drawing elements; ZOOM PREVIOUS returns the display to the previous view; ZOOM MAGNIFICATION specifies the size of the new view as a ratio to the total drawing or to the current display; ZOOM WINDOW allows the user to specify the new view by using the pointing device in order to define the lower left and upper right corners of a window.

The viewport can be repositioned, at the same scale, with the PAN command, which prompts for a displacement vector that can be entered with the pointing device. AutoCAD's PAN command operates as if the drawing is being moved under the viewport; some CAD programs are the opposite. AutoCAD allows users to name specific areas of the drawing and recall them by name with the VIEW command. This provides quick display of the parts of a drawing that are required often, such as the rooms of a house plan or subsystems in a large schematic.

The ZOOM, PAN, and VIEW commands cause the screen to go blank and the drawing to be redrawn. Other commands leave the display intact, but leave markers behind. The REDRAW command is used to remove the markers.

Redrawing the screen can be a slow process when drawings become large and complex. Turning off the FILL and QTEXT commands can speed up the redrawing process. When FILL is on, solids and traces are filled in, which can be quite time-consuming. When turned off, shapes are displayed as outlines. Displaying text also slows down redrawing. When QTEXT is off, text is just indicated with boxes.

LAYERED DRAWINGS

AutoCAD's layering capability is both a display control and a drawing aid. The manual compares the layering process to the transparent sheets of mylar used

in conventional overlay drafting. In overlay drafting, registration of layered drawing objects is maintained by punching holes in the mylar and then placing them over a pin bar.

Actually, a layer is more like an attribute that is assigned to each drawing object. The LAYER command sets the current layer, which is the attribute value assigned to objects as they are created. The default current layer in a new drawing is layer 0. Layers can be turned off and on at any time with the LAYER command. If two layers are defined in a drawing, say 1 and 2, all the objects with the layer attribute set to 1, but not those with the attribute set to 2, can be displayed by turning layer 1 on, and layer 2 off.

A layering capability is necessary for a serious CAD program, and AutoCAD offers a more powerful and flexible facility than most systems. Even Intergraph is limited to 63 numbered levels. AutoCAD allows an unlimited

Limits can be set from 10E-99 to 10E99 in the X and Y dimensions, so for all practical purposes a drawing can be infinite.

number of layers, which can be named with English words or numbers.

In addition to turning layers off and on, the LAYER command can be used to associate color and line-type values with each layer. If the appropriate color/graphics adapter is installed, AutoCAD displays layers in color; if not, the color attribute still can be used in the plotting of drawings. AutoCAD's basic design provides for the assignment of 255 colors, although few displays take advantage of that capability. The line-types can be displayed with all graphics adapters—the program includes a library file that contains eight types of broken lines in addition to the default continuous line-type; the manual explains how to define other types of broken lines if the supplied assortment is not adequate.

The layer facility is impressive, but carries a hidden danger. The editing commands (covered below) affect only the layers that are turned on. For example, if the MOVE command is used to move the floor plan of a building with

the Door layer turned off, the doors will remain in their original positions. The OOPS command, which unerases the last object erased, does not unmove or unchange objects. This means that a user must make sure all layers are turned on before moving substantial parts of a drawing.

AutoCAD 2.1 has enhanced the layering feature to help speed the redrawing process. During a redraw, the program scans all objects regardless of the ON/OFF status of the layers. Thus, redrawing a display in which the layers are turned off takes just as long as when all the layers are turned on. FREEZE and THAW options for the LAYER command can prevent the program from scanning "frozen" layers. In all other respects the frozen layers behave as if they are turned off.

DRAWING AIDS

AutoCAD 2.1 provides a class of commands, appropriately called drawing aids, that generally speed the process of drawing and allow more effective use of the program's precision.

A precision of 14 decimal digits is possible in AutoCAD; coordinates are displayed to four decimal digits by default. In contrast, digitizers typically have a resolution of .001 to .01 inches, and plotters usually plot drawings with a resolution of .001 inches, using pens on the order of .01 inches in diameter. AutoCAD accepts coordinates as they are typed on the keyboard; at small scale displays, positioning the pointing device to obtain the desired coordinates often is not possible.

The SNAP command ensures that objects are entered at specified intervals. Laying out a printed circuit board, for example, may require drawing pads spaced at .10 inches, with a precision of .0001 inches; SNAP can set the snap resolution to a .10-inch grid, the limits of AutoCAD's precision. When a graphic data point is entered, it "snaps" to the nearest .10-inch increment from the origin. Once set, the SNAP mode can be turned off and on with the SNAP command, a function key, or a control key combination.

With the SNAP mode on, ensuring that lines are orthogonal (perfectly vertical or horizontal) is relatively easy; without the SNAP mode, it is not. In these cases, the ORTHO mode can be used to enter perfectly vertical or horizontal lines. The ORTHO mode also ensures that arcs end only at quadrant boundaries—0, 90, or 270 degrees.

AutoCAD can display a grid of dots spaced at the SNAP interval, a multiple

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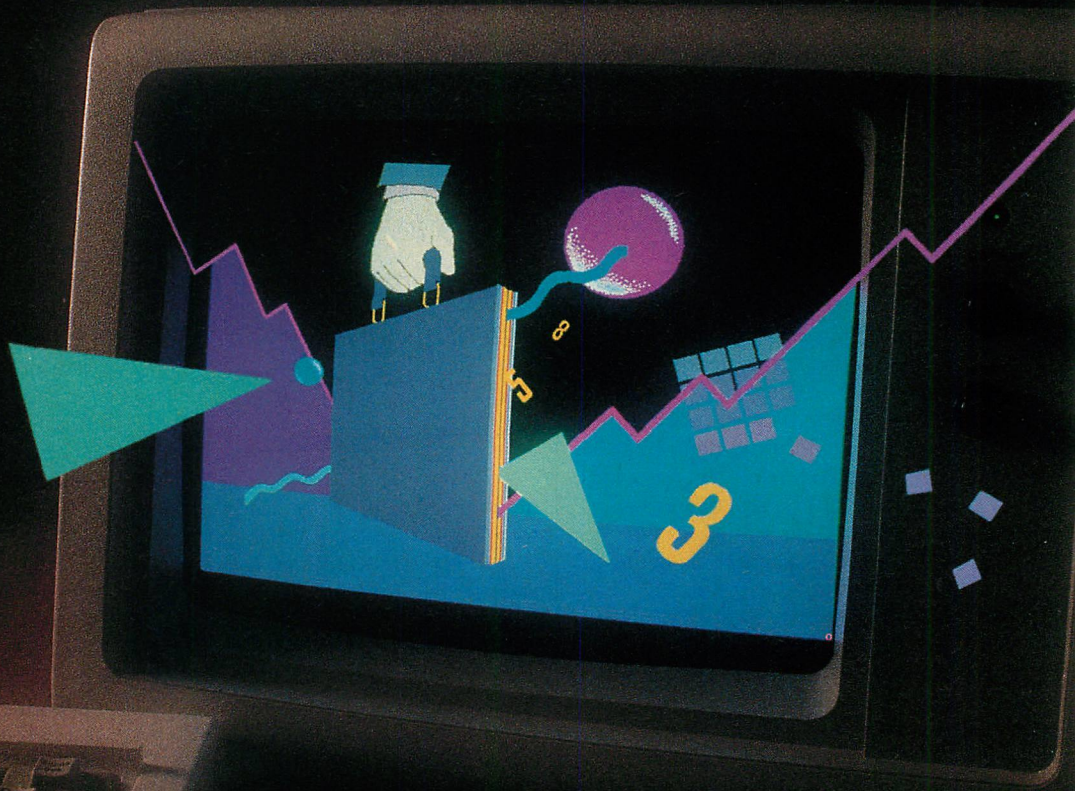
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of the SNAP resolution, or at some arbitrary interval. It helps the user to maintain orientation to the drawing, particularly to the relative size of the display, and to make quick estimates of the dimensions of objects. The extent of the displayed grid is determined by the limits set for the drawing. The grid can be turned off and on using GRID, a function key, or a control key.

The grid, which covers the screen with dots, can be distracting, so the user may wish to replace it with tick marks. The AXIS command displays a ruler along the *X* and *Y* axes, marked with tick marks at user-specified intervals. These provide essentially the same benefits as the grid provides.

With ADE 2, the grid becomes more powerful than with the basic program. It can be rotated to increase the speed with which lines can be entered at arbitrary angles. Two styles of the grid are available—a rectangular grid and an isometric grid. The isometric grid facility also can change the cursor from one side of the isometric cube to another. Finally, the aspect ratio of the grid can be changed from the standard 1:1 to any arbitrary value.

ADE 2 offers other valuable drawing aids, including an object snap capability that allows entry of data points by naming geometric features of existing drawing objects, rather than by actually positioning the cursor at the correct data point. For example, to specify that a line segment begins at the end of an existing line segment, entering END in response to the From Point prompt of the LINE command causes the program to prompt for a drawing object. Selecting the previously defined line snaps the cursor to the end of the selected line and enters that point as the first endpoint of the new line.

ADE 2's object snap facility also can specify that data points snap to the midpoints of lines or arcs; to arc or circle centers; to intersections of two lines, a line and an arc, or two circles and/or arcs; to the insertion point of a block; or to a quadrant point of a circle or arc. The PER and TAN options specify that a line segment be entered perpendicular to another line segment or tangent to a circle or arc.

COMPLEX OBJECTS

A common reaction to a CAD demonstration is, "I could have drawn it faster by hand!" However, that reaction is heard less often after a demonstration involving complex objects. AutoCAD 2.1 handles complex objects with two basic commands: BLOCK and INSERT.

An arbitrary number of drawing objects can be grouped together and assigned a name with BLOCK. Copies of that group can be placed anywhere in the drawing with INSERT.

Most of the editing and inquiry commands apply to blocks as well as to primitive objects. After a block has been INSERTed in the drawing, it can be moved, erased, copied, mirrored, or arrayed with a single reference.

The drag mode applies to the insertion of blocks that can be dragged into position to the correct scale, aspect ratio, and rotation. Photo 2 shows a housing site where each of the houses are blocks that have been assembled into a larger drawing.

Blocks can be inserted at varying

A layering capability is necessary for a serious CAD program, and AutoCAD offers a more powerful facility than most systems.

scales in both the *X* and *Y* directions, allowing unit-sized blocks to be used at different sizes. The INSERT command syntax provides for separate entry of *X* scale, *Y* scale, and rotation angle. Specifying a negative scale factor mirrors the block in that direction.

A block's components are listed only once in the drawing file, and that definition does not produce a visible display. All the visible instances of the block are produced by block references. The INSERT command creates the block reference.

Blocks can be redefined by specifying the name of a different block when using the INSERT command or by editing the block definition. Editing a definition is accomplished by inserting the block's name preceded by an asterisk, which inserts all the components listed in the block definition rather than making a block reference. These components then can be edited and regrouped with the BLOCK command, using the original name. AutoCAD always cautions the user that the block already exists and requires a confirmation. When a block is redefined, AutoCAD redraws the screen, updating all instances of the inserted block.

The block facility is one of the features that allows AutoCAD to be cus-

tomized. The WBLOCK command writes blocks out to individual disk files for use in other drawings. Symbol libraries, or collections of disk files created with WBLOCK, can be created by the user or purchased from third-party vendors. AutoCAD offers several libraries aimed at the architectural/engineering/consultant market. Symbol library packages usually include some form of custom menu to reduce the need to learn a long list of symbol names.

A block created with the WBLOCK command is a complete drawing file. Just as that file, containing a single block can be inserted into another drawing, so can any drawing file be inserted into the current drawing, as blocks or *blocks. Thus, complex custom drawings can be assembled from standard details and drawings of standard components.

EDITING AND INQUIRY

A CAD program shares many features with database management systems. Indeed, a DBMS is an essential part of a CAD program. Its operation is apparent in the use of AutoCAD 2.1's editing and inquiry commands. These commands typically work with primitive objects and blocks in the same manner.

Any currently displayed object can be moved with the MOVE command, copied with the COPY or MIRROR command, and changed with the CHANGE command. Multiple copies of objects can be created with the REPEAT or ARRAY command, and objects can be erased with the ERASE command.

Other editing commands include FILLET, which connects two lines with an arc of specified radius, CHAMFER, which connects two intersecting lines with a line segment inclined to both segments, and BREAK, which partially erases objects. FILLET and CHAMFER work with polylines as well as with ordinary line segments.

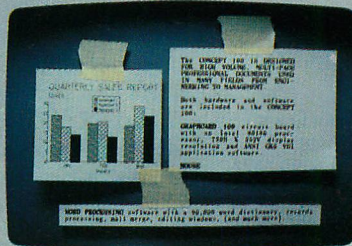
AutoCAD's editing commands provide several ways to indicate which objects are to be edited. Objects can be selected by positioning the cross-hairs of the screen cursor over the object and then pressing the Return key, the Space bar, or the appropriate button on the pointing device. Objects also can be selected with a window by drawing a box with the pointing device. Finally, the last object that was created can be selected with the LAST option.

The MOVE and COPY commands require displacement vectors, which are most easily entered with the pointing device. If the ORTHO mode is on, only orthogonal displacement vectors can be

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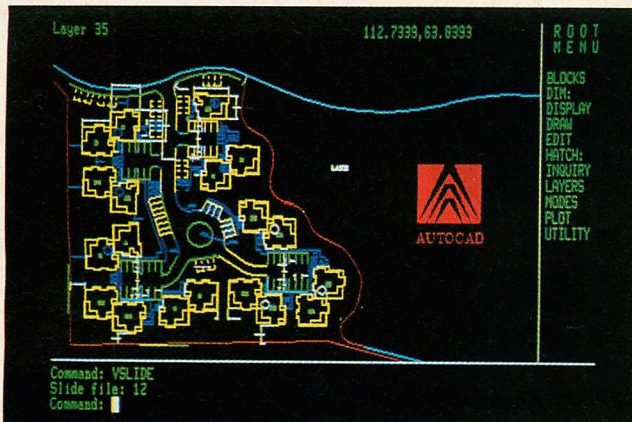
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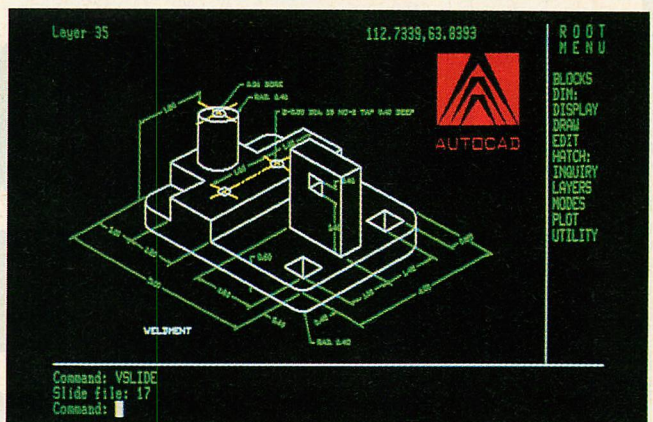
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PHOTO 2: *Predefined Blocks*

The ease of making complex drawings is demonstrated using the house as a predefined block in a housing project layout.

PHOTO 3: *Dimensioning Feature*

AutoCAD's limited three-dimensional capability and its dimensioning feature are illustrated in this photo of a weldment.

entered, and if the SNAP mode is on then only displacement vectors that begin and end on the SNAP interval can be entered.

AutoCAD 2.1 introduced an interactive method of selecting objects for editing or inquiry commands. Commands that require selection of objects prompt for the objects with the prompt, "Select objects or Window or Last." As each object or group of objects is selected, it is indicated with a change in color or line-type, and the prompt is repeated. The command is executed when the prompt is answered with the Return key or Space bar.

The DBMS-like inquiry commands include LIST and DBLIST, which, respectively, display the records of selected objects or the entire drawing database. Objects can be selected by pointing and picking, with a window, or with the last option.

Other inquiry commands include DIST, which displays the distance between two points, ID, which displays the coordinates of a point, and AREA, which calculates the area and perimeter of an object enclosed by an imaginary polygon specified by an arbitrary number of specified points.

Polylines must be edited with a special command, PEDIT, with the exception that they can be FILLETED and CHAMFERED. Some of PEDIT's numerous options resemble other commands, but apply only to polylines. Other options have no counterparts, requiring the user to learn new concepts. Nevertheless, the command is powerful, and allows the user to change the width of one or all segments, create tapered segments, open a closed polyline or close an open polyline, remove curves between vertices, fit curves through ver-

tices, and add, move, or remove vertices. As mentioned earlier, contiguous lines and arcs can be converted to single polylines with the PEDIT command.

NONGRAPHIC ATTRIBUTES

AutoCAD 2.1 takes the DBMS aspect of CAD further than many CAD programs. Nongraphic attributes can be associated with blocks of graphic objects. The association is established with the BLOCK command. Attributes are defined with the ATTDEF command and can be visible or invisible, variable or constant.

When a block that has attributes associated with it is inserted, the program prompts for values for the variable attributes. When the required values have been supplied, the program draws the block, displays the values of the visible attributes, and stores the values of the invisible attributes.

At any time, the attributes in a drawing-file can be extracted, producing an output disk file containing the attribute entities in a form suitable for further processing. Any one of three output file formats can be specified: one suitable for processing with BASIC programs, one with dBASE II, and one that is similar to the drawing exchange file (explained below). Attributes can be edited with the ATTEDIT command.

The AutoCAD package includes some sample programs, written in BASIC, which produce bills of material and cost estimates from sample extract files, which are also provided.

The attribute capability brings AutoCAD 2.1 much closer to a large CADD program than did its earlier versions. The ability to attach nongraphic data to objects and to process that data externally is a key to adding design capabilities to the basic CAD software.

Some microcomputer CADD programs are available that make use of nongraphic data to perform design functions—Personal Cad Systems' line of electronic circuit board design programs is a good example. However, many of these programs are dedicated to a particular design task. AutoCAD has provided a general capability that can be adapted to a variety of design tasks, including NC (numerical control) part programming, interior design, landscape design, and others.

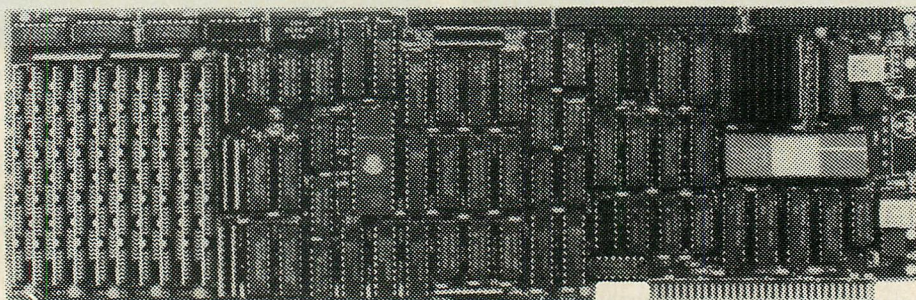
SOME SPECIAL FEATURES

AutoCAD 2.1's special features include dimensioning, cross-hatching, and script capabilities. The semiautomatic dimensioning feature will calculate dimensions given two points—extension line origins—or the selection of an object. The program will dimension linear distances, angles, diameters of circles, and radii of circles and arcs. Photo 3 shows the dimensioning feature of AutoCAD with three-dimensional visualization. The program provides control over 17 dimensioning variables, so that several dimensioning conventions can be accommodated. However, dimensions are not bound to drawing objects. If a dimensioned object is changed in size or location, the dimension will not be changed accordingly.

Cross-hatching or pattern-filling are time-consuming operations when performed manually. AutoCAD 2.1 provides a HATCH command, with several options to indicate the area to be hatched. The package includes a library of patterns, but additional patterns can be defined, if desired, and stored in a library.

The HATCH command has some drawbacks. Certain rules must be followed when entering the drawing enti-

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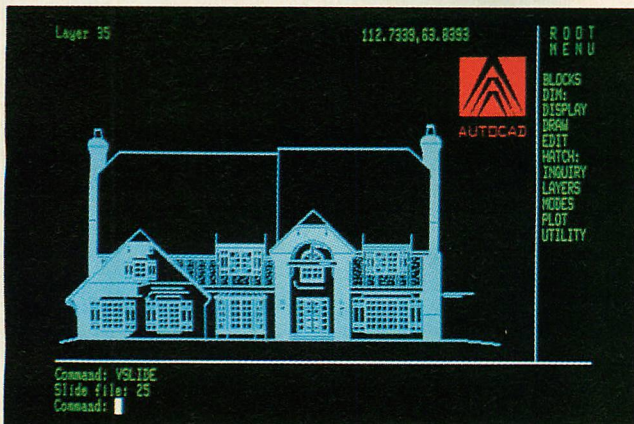
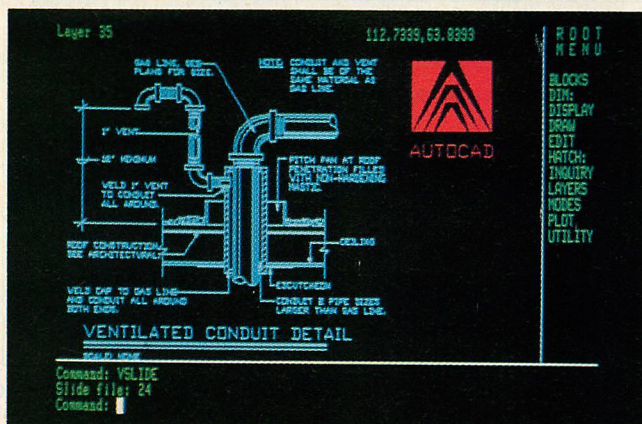
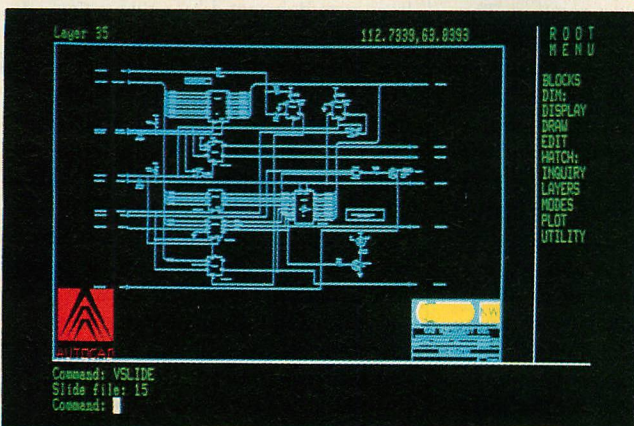
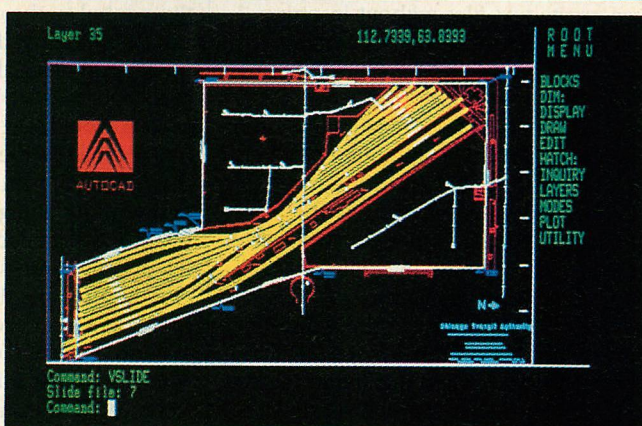
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PHOTO 4: *Architectural Drafting***PHOTO 5:** *Mechanical Drafting***PHOTO 6:** *Electronic Drafting***PHOTO 7:** *Civil Engineering*

AutoCAD 2.1 can be used in any situation that requires two-dimensional drafting. This includes architectural, as shown by the elevation of a house in photo 4; mechanical, as seen in photo 5; electronic, demonstrated by the schematic in photo 6; and civil engineering, as in the routing of train tracks shown in photo 7.

ties that will form the boundary of the area to be hatched. Hatching can be slow, especially if a small pattern is specified, and stopping the program from finishing the hatching operation is not always possible. Fortunately, a hatch pattern can be erased with a single command—ERASE LAST. Hatch patterns take up a lot of disk space, especially if the pattern is small. However, with judicious use, the HATCH command offers a facility for dressing up a drawing.

Another special feature, important for presentations, is the facility for executing command scripts. A command script is a text file of AutoCAD commands and can be created with any text editor that does not place control characters in the file. The main program can be invoked with the script file as a parameter, and AutoCAD will execute all the commands in the file. This facility can demonstrate the creation of a drawing or display various parts of the drawing without the need for an operator.

AutoCAD has a slide-show facility that can be used in a script file automatically to display a series of named views.

Another use for the script facility is for repetitive tasks, such as setting up drawing limits and drawing borders and title blocks on new drawings. A script file can be executed from within the drawing editor with the SCRIPT command, which can be entered from the command line or with a menu selection. This command can be an element of a menu selection, providing the capability of calling a standard subroutine or procedure from disk, rather than having it stored in the actual menu.

DESIGN EXTENSIONS

AutoCAD's ADE 3 package has two facilities that are certain to encourage the development of third-party design extensions. The first is the ability to define named variables, assign values to them, and supply variable names in response to prompts for data. In addition, the

manual lists a page of predefined system variables, all of which can be accessed and assigned new values.

AutoCAD variables, which can assume four types—integer, real, point, and string—can be used in expressions entered in response to prompts or as prompts in custom menus. The syntax of the expressions resembles that of the LISP language. The expression facility includes arithmetic, trigonometric, and geometric functions, string functions, conditional expressions (predicates), special data input functions, and display control functions. The expression interface does not include all LISP statements, but the basics are there, including CAR, CDR, CADR, LIST, and SETQ. This allows the user to write custom menus in which each selection is a short LISP-like program, prompting for information, performing calculations, and returning numeric or string results.

The standard menu, ACAD.MNU, is a text file and can serve as the basis of

FIGURE 1: *Piping Menu*

<pre> **PIPING 1 [SETSIZE]\$S=SETSIZE [90' ELL]INSERT (STRCAT "9LR" (STRCAT LINESIZE "BW")) \1 1 DRAG \ [45' ELL]INSERT (STRCAT "4LR" (STRCAT LINESIZE "BW")) \1 1 DRAG \ [LASTMENU]\$S= [ROOTMENU]\$S=S </pre>	<pre> **SETSIZE [SETSIZE] [MENU] [10"](SETQ LINESIZE "10-") \$S= [12"](SETQ LINESIZE "12-") \$S= [14"](SETQ LINESIZE "14-") \$S= [16"](SETQ LINESIZE "16-") \$S= [*CANCEL*]^C\$S= </pre>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Two subroutines, PIPING and SETSIZE, are inserted into the ACAD.MNU file. Selecting the PIPING option from the custom main menu provides the options that are now available: SETSIZE, 90-degree ell, or 45-degree ell.

a custom menu. The only requirement is a text editor or word processor that can create text files without inserting control characters. The basic menu can be extended with additional submenus and menu selections.

As an example of creating a custom menu, ACAD.MNU is modified to add a selection called PIPING to the root menu. This is done by adding the line [PIPING]\$S=PIPING in ACAD.MNU after [UTILITY]\$S=UT and by adding the piping menu shown in figure 1. The expression [PIPING] causes the word PIPING to be displayed below UTILITY in the menu area. When this item is selected, the expression \$S=PIPING replaces the root menu with the piping menu.

Figure 1 shows three new selections and allows the return to the previous, or root, menu. SETSIZE changes the LINESIZE variable, which stores a string indicating the size of the piping to be drawn. The line size is stored as a string variable so it can be concatenated with other string variables and constants to form a block name for use in an INSERT command. The SETSIZE selection, which does not affect the drawing in any visible way, must be made before the first fitting can be added; if no value has been set, the 90-degree ell will not have a size and cannot be inserted.

The two other selections are 90- and 45-degree ell fitting. Although these selections are INSERT commands, they assemble the block to be inserted from the variable values 9LR for 90-degree fittings and 4LR for 45-degree fittings, the value assigned in the last LINESIZE command and BW to construct a full block name. As an example, if the LINESIZE selected were 10 inches and a 90-degree ell was requested, the block to be inserted would be named 9LR10-BW.

This particular scheme uses a separate file for each fitting; the command

sets the X- and the Y-axis scale to 1 automatically and allows the user to drag the symbol to the correct rotation. The insertion point is the fitting's work point, so rotating the fitting accounts for both right and left turns. Another approach would have been to define the fitting's inlet as the insertion point, but that approach would have required the option of inputting positive and negative Y-axis scale factors to provide for left and right turns and would not as closely resemble the manner in which piping designers actually lay out piping systems. Selecting one of the options, "45' ell" or "90' ell," causes the block to be recalled from the disk. The insertion point should be typed in from the keyboard and then the block can be rotated into its final position.

A precautionary note is in order: every character in a menu selection is significant. That means an error as subtle as an extra space at the end of a line added to the custom menu can cause difficulty—in fact, the extra space will repeat the command, but will do so as if the command had been typed in at the command prompt. Another precaution: the parentheses in AutoCAD's expressions, like those of LISP, are plentiful and significant. The manual does not mention the consequences of mismatched parentheses. If an expression has more lefts than rights, AutoCAD assumes the complete expression has not been entered, and it displays a prompt such as "1>," or "2>," or "n>," depending upon how many right parentheses are missing. Executing the same expression again will merely display a prompt with a higher number. To return to the command prompt, the user must enter the correct number of parentheses and remedy any side effects that may have occurred. Nevertheless, AutoCAD's expressions and variables

are a worthwhile addition to the program. The piping menu example used here was debugged by using a text editor and tested by reloading AutoCAD.

The second new facility included in ADE 3 that will encourage the development of third-party design extensions is one that allows the user to execute external commands and programs without leaving the AutoCAD program. The external commands to be executed are listed in a disk file that must be present when AutoCAD is loaded. As with menu files and script files, the external command file, ACAD.PGP, is a text file that can be created or edited with a word processor or text editor. The package includes a sample ACAD.PGP file, which includes several DOS commands.

The external command facility lessens the difficulty of entering and editing text by using a word processor and the AutoWORD program, executes DOS internal and external commands, processes drawing attributes with database management programs, and executes various custom programs. One of the programs accommodated by this feature is the CAD/Camera program that translates binary image files produced by the Datacopy Image Scanner system into vector files for use in AutoCAD.

Although the ACAD.PGP file is easily created or modified with a text editing program, some knowledge of AutoCAD, the external program, and DOS itself is required. Each external command is listed in a line that also includes the name used to execute the program from AutoCAD, the string sent to the operating system to run the program, the amount of memory that the external program needs for execution (the amount must be sufficient to contain DOS' COMMAND.COM file), a prompt for programs that require entry of command line arguments, and a re-

turn code that instructs AutoCAD to perform certain tasks when the external command has been completed.

PLOTTING

For many designers, a plotted drawing is the end product. In AutoCAD, drawings can be plotted as a selection from the main menu or with the PLOT command from within the drawing editor.

Prior versions of AutoCAD plotted the drawing as it was last displayed on the screen, so it was advisable to end drawing sessions with the entire drawing displayed or to plot only from within the drawing editor.

In AutoCAD 2.1 when the PLOT command is given, the program prompts for the portion of the drawing to be plotted: Display, Extents, Limits, View, or Window. Once that prompt has been answered, the program displays several parameters and asks the operator if there are any changes. Pen numbers can be assigned to colors, so drawings can be plotted in color or with various line widths. Layers can be assigned colors, which means that pen numbers can be assigned to layers.

The plotting area or media size can be set in inches or metric units, and the origin of the plot on the media can be set in drawing units, which correspond to real-world units. Two-dimensional plots can be rotated 90 degrees, and three-dimensional plots can be processed for hidden line removal. The last piece of information supplied to the program is the scale of the drawing.

An advantage of CAD is that the user does not need to be concerned about scale until the drawing is ready for plotting. Some planning is required, however. If a drawing of a building eventually will be plotted to a scale of $\frac{1}{8}$ inch = 1 foot, text must be entered at a height of 6 inches to be $\frac{1}{8}$ -inch high when plotted; AutoCAD's default text height of $\frac{3}{16}$ inch (drawing units) would be illegible. The drawing limits should correspond to the size media the drawing will be plotted on.

COMMUNICATION

AutoCAD has established a data exchange format (DXF file) that is documented in the manual. The DXFOUT command instructs the program to process a drawing file (DWG) and to produce a drawing exchange file (DXF). The DXF file is an ASCII text file that can be typed on the screen, processed with an editor or a design program, and printed. The processed DXF file can be read by the AutoCAD 2 program to produce a revised DWG file, via the DXFIN

command. Conceivably, a design program could generate an entire drawing using this facility.

Third-party vendors have taken advantage of this facility by writing programs that translate DXF files to similar files for other systems. In this way, an AutoCAD system can be used as a workstation on a large CADD system (translators are available for the AutoTrol and Intergraph systems). The benefits of using an AutoCAD system as a workstation are obvious—\$6,000 versus \$60,000. In fact, Intergraph has introduced a workstation that can be used as a stand-alone DOS-based computer.

AutoCAD 2.1's performance can be enhanced in the form of programs that process DXF files, symbol libraries, and custom menus.

This same facility allows AutoCAD 2.1 to be the basic software component of a more comprehensive CADD system. In fact, several other microcomputer-based CAD programs make use of the DXF file, in an effort to achieve some measure of standardization.

AutoCAD's DXBIN command provides another communications facility. This command is included to provide for loading binary image files produced by the CAD/Camera and similar programs. CAD/Camera translates binary image files produced by Datacopy's Image Scanning system into vector files that can be loaded into a drawing file.

FAVORABLE PERFORMANCE

A single-user AutoCAD system running on a suitably configured computer seems to compare favorably to larger CADD systems supporting the maximum recommended number of users. Even large systems performing complex design tasks, such as isometric extraction, are less than instantaneous. Of course, a large system supporting one or two users and performing basic drafting tasks is much more impressive and considerably more powerful than any microcomputer-based system.


Like all powerful computer programs, AutoCAD demands practice. The manual is not intended to be a tutorial, although it does present the various commands in a logical, first-steps-first

manner. Because AutoCAD is the top-selling microcomputer-based CAD system, a number of outside training aids are currently available for it: tutorial disks, books, self-study courses, seminars, and training centers.

The key to learning to use AutoCAD effectively is to understand the principles of design and drafting. The program follows conventional drafting practice quite closely. Anyone who is accomplished in manual techniques should be able to use AutoCAD effectively after only a few days. Virtuosity may take longer.

AutoCAD 2.1 is an impressive performer. It has a wide range of facilities, and the list has grown steadily since the program's introduction. Furthermore, AutoCAD's performance can be enhanced by the user or by third-party software vendors in the form of programs that process DXF files, symbol libraries, and custom menus.

The real power of AutoCAD or any CAD system becomes apparent when designers have accumulated a library of standard symbols. Third-party software vendors offer many such packages, but users may create their own libraries. As the symbol library grows, the drawing process becomes more efficient; standard symbols can be inserted rather than drawn from scratch.

CAD systems were developed to make the drafting process faster and more efficient, thereby saving time and money. AutoCAD is capable of automating virtually any production drafting task. Even if original drawings are produced at only a moderate savings in time and effort over manual methods, changes can be accomplished much faster on the CAD system. Major revisions can be made and the drawing replotted in a fraction of the time required for reworking a conventional drawing. A draftsman who is moderately proficient at using AutoCAD can produce drawings faster than he or she could do manually, and a very proficient user should at least double the productivity of manual methods. 

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Victor E. Wright is the manager of process engineering at Luckett & Farley, located in Louisville, Kentucky. He has written two books that deal with CAD and software.

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Drawing Toward Monochrome

Once an unattainable goal, 640-by-200 or 320-by-200 graphics on a monochrome display now is possible with each of the five cards reviewed here.

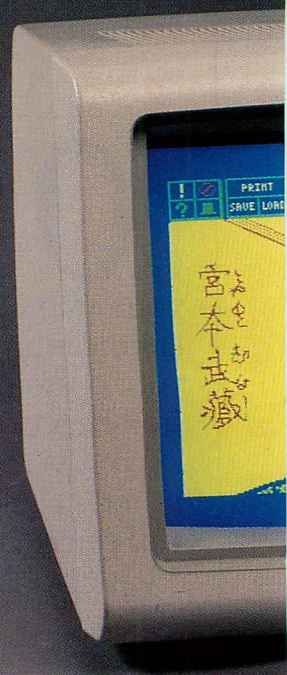
PETER AITKEN

The choice between the graphics capabilities of a color/graphics card and the sharp, clear characters of a monochrome card has traditionally plagued personal computer users. Short of operating a two-card, two-monitor computer system, the combination of extensive graphics capabilities and a monochrome display has been virtually impossible.

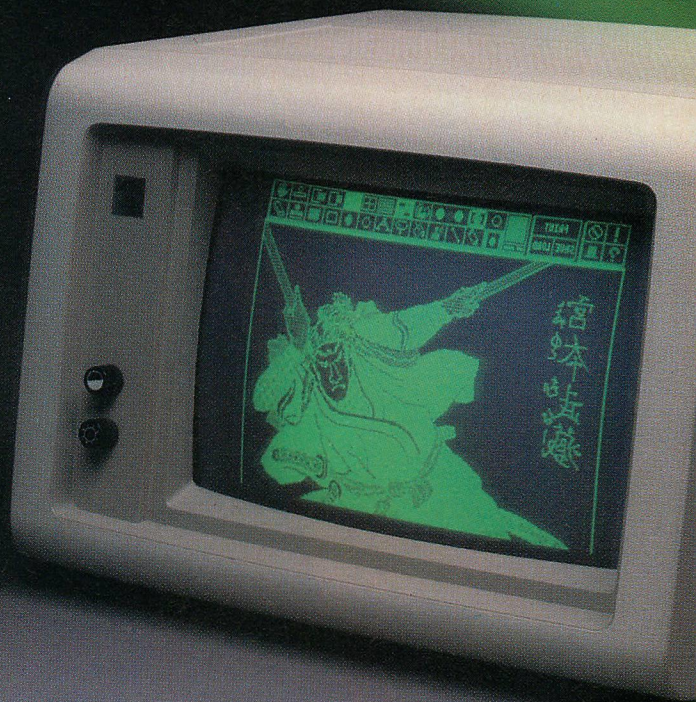
The Hercules Graphics Card brings some graphics powers to a monochrome display while retaining excellent character quality, but the Hercules card and its clones have a severe limitation; they require special driver programs to allow individual software products to create graphics using the cards. These cards are best for use with popular commercial software packages that are already equipped with drivers. They offer no help to users running home-grown graphics software or com-

mercial products for which no driver program is readily available.

Recently, a number of new graphics cards has been introduced that permit *any* program to do IBM 640-by-200 or 320-by-200 resolution graphics on an IBM (or equivalent) monochrome monitor. The new cards, which include the Everex Graphics Edge, Genoa Spectrum, Paradise Modular Graphics Card, STB Chauffeur, and Tseng UltraPAK, appear to be nearly 100-percent compatible with the IBM Color Graphics Adapter, while retaining the ability to drive a monochrome display. All of them resemble the monochrome adapter when in text mode. When CGA-compatible graphics calls are generated by an application, driver software in RAM (or, in the case of STB Chauffeur, in on-board ROM) intercepts the graphics BIOS calls and writes directly to graphics RAM, remapping the informa-



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tion onto the larger (usually 720-by-348) graphics screen format.

Everex Graphics Edge. The Graphics Edge Card is the one exception among the five cards reviewed that does not expand the 640-by-200 display to fill the entire monochrome screen. The display on a monochrome monitor in color mode is compressed to use the central 640-by-200 points of the screen's overall 720-by-348 resolution, resulting in a severely distorted display.

Graphics Edge can be operated in either monochrome or color mode. The mode in which the computer is booted is set with DIP switches 5 and 6 on the system board switch block SW1; once the computer is booted, software can be used to switch the mode. Only an IBM or equivalent monochrome monitor can be driven in monochrome mode. In color mode any combination of RGB, composite, and monochrome monitors may be used, with the same information displayed on each.

Resolution on a monochrome monitor is 720-by-348 with a 9-by-14 character box. All pixels on the 720-by-348 grid are individually addressable. Graphics Edge contains 64KB of video memory and comes with a variety of programs for setting video modes and switching between them. Included are programs for 132-column by 25- or 44-row text modes, which can be used with Lotus 1-2-3, among other programs. Graphics Edge has the ability to produce the same display on two monitors simultaneously.

The Graphics Edge card has two nine-pin monitor sockets, one for RGB color and one for monochrome. It also has a composite monitor plug and a small toggle switch with positions for color and mono. A printer port and light-pen connection are built in. No piggyback add-ons are provided. The printer connection is via a 12-inch cable that plugs into the card inside the computer, snakes out between mounting brackets, and has a standard female printer socket on the other end.

The Graphics Edge manual's strong point is its fairly clear and complete technical section, that includes assembly language source code for some of the mode-setting programs as well as some sample BASIC programs for drawing circles and cubes. Otherwise, the manual leaves much to be desired. Information on the various aspects of using the card, such as jumper-selectable options, monitor connections, motherboard switch settings, and mode selection, are scattered throughout the manual more or less at random. This organization is

particularly unfortunate given that Graphics Edge is quite complicated to install and configure.

Everex has released a new product, the Everex Edge, which addresses many of the problems of the Graphics Edge card. It expands the graphics raster to fill the entire monochrome display area; it has several new text modes, including a 132-column mode, but lacks the composite video output jack. It was not available for this review.

Genoa Spectrum. This card can drive an IBM monochrome display or an RGB display; a jumper on the card determines which signal is generated. Spectrum has a nine-pin monitor socket and a parallel printer port, which is configured as LPT1 and is enabled or disabled by a jumper on the card. A light pen can be connected directly to the card.

Genoa Spectrum comes with only two programs, SM.EXE and SM2.EXE, which are used to switch between the various display modes. The programs do essentially the same tasks: SM is used when Spectrum is the only video card installed; SM2 is used when two

Hercules and its clones have a severe limitation; they require special driver programs to allow each software product to create graphics using the card.

video cards are installed. The programs can be used as either menu- or command-line driven. In the former case, the desired mode is selected from the menu presented when the program is called up. Alternatively, the program is invoked with a parameter that specifies the mode desired. For example, the command SM MGF <enter> puts the card in the monochrome graphics full mode, which corresponds to the Hercules HGC full mode. Plantronics mode is also supported, as is 132-column by 25- or 44-row monochrome text mode. The 132-column mode works only with software that supports it, however, because Spectrum does not come with special 132-column drivers.

These mode-setting programs are simple to use and appear to work perfectly. The command-line feature allows the user to invoke a particular video

mode from an AUTOEXEC.BAT file. However, the SM.EXE file is more than 23KB, a significant amount of disk space. In addition to SM and SM2, Genoa should supply stand-alone programs to set each individual mode. This would save space on program disks that require only one video mode.

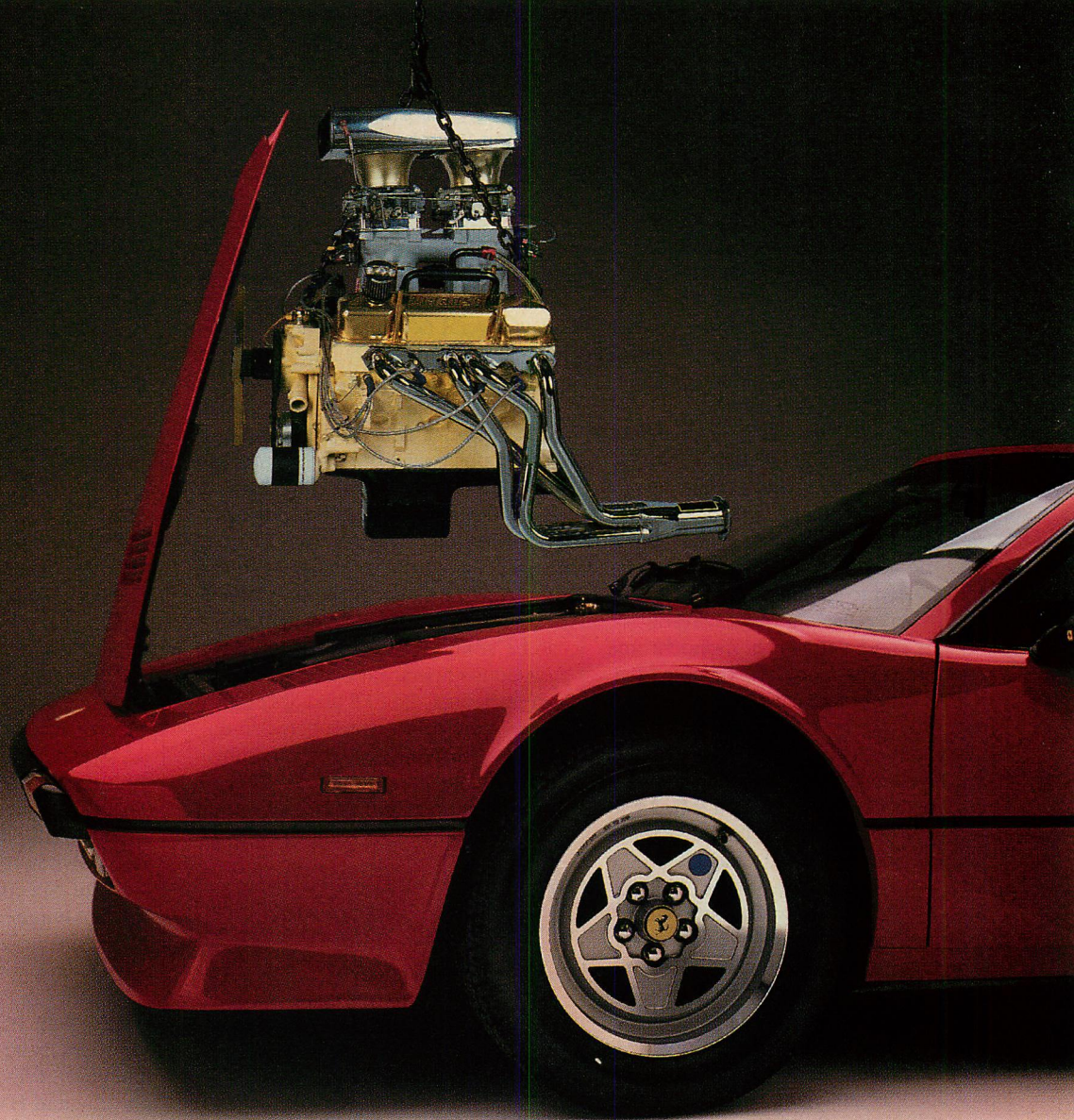
Spectrum's text character box is 9 by 14, and resolution is 720 by 348 on a monochrome monitor, with all pixels individually addressable. The card has 64KB of video memory, the addresses of which are B0000-B7FFF for monochrome text modes, B8000-BFFFF for color and emulation modes, and B0000-BFFFF for monochrome graphics mode.

The Spectrum manual contains detailed information on programming the video memory and control ports. In general, the manual is very clear and well organized and earns particularly high marks for a detailed series of possible configurations, with instructions on switch and jumper settings and default capabilities for each configuration. This explanation makes installation of the Spectrum board among the easiest of the five reviewed.

The Spectrum manual includes a list of computers and monitors that have been tested and found to work satisfactorily with the card. Computers listed are the PC, PC/XT, PC/AT, Columbia PC, Tava PC, and Tandy 1200PC; monitors listed are IBM monochrome and color, Princeton MAX-12 monochrome and HX-12 color, Taxan 420 and 425 color, and Quimax PX-IV. The following monitors are specifically recorded as having "one problem or another" with the Spectrum card: Amdek 310A, Quimax DM-14, and Taxan 121 (all are monochrome). Genoa deserves credit for freely admitting to these incompatibilities.

Paradise Modular Graphics Card. The Paradise card has a nine-pin monitor socket, to which either a monochrome or RGB monitor can be connected. Jumpers on the card must be set for the type of monitor that is being used. On an IBM or equivalent monochrome monitor, this card provides text characters as 7 by 9 in an 8-by-14 box. This implies an effective resolution of 640 by 350; however, Paradise is not programmable as a 640-by-350 graphics device.

The card has 16KB of video memory starting at B8000H and emulates all the CGA text and graphics modes. It supports both the 320-by-200 and 640-by-200 CGA modes, although in a peculiar fashion: each of the 200 vertical scan lines is doubled to produce a display resolution of 400 pixels vertically.



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Unfortunately, this doubling is done for the display only; not all 400 vertical pixels can be addressed individually.

The Paradise card provides for two piggyback boards, or modules, that allow memory and other features to be added without taking up additional expansion slots. The card can hold one type A and/or one type B module. Currently available modules are 64KB-256KB memory with clock/calendar (type B), 64KB-384KB memory (type B), floppy-disk controller with parallel printer port (type B), serial port (type A), and parallel printer port (type A). Even with two modules attached, the card fits into the narrow expansion slots of the PC/XT. A light-pen interface is also built into the card.

The Paradise graphics card requires no special software to drive an RGB monitor. If a monochrome monitor is being used, however, a configuration program must be run every time the computer is booted. Otherwise, only half of each line of characters will appear on the screen. Paradise makes this process totally painless; as soon as the card is installed, the user needs only to turn on the computer with the Paradise software diskette in drive A: and follow instructions.

Paradise supplies a program called MGPREP.COM that generates configuration programs, easing the burden of having to copy the configuration program on every disk used to boot the computer. MGPREP.COM presents the user with a table listing the various features available, including not only the type of monitor being used, but also RAM disks, print spooler, serial port configurations, and clock module usage. After the user selects the desired features, the MGPREP program writes to the boot disk a configuration program, called MGC.COM, that will set up the computer as indicated. MGPREP will even write or modify AUTOEXEC.BAT so that the first program to run when the disk is booted is MGC.COM, which must be the first resident program installed in order to work correctly.

The 5½-by-8½-inch Paradise manual is presented clearly and logically and can be inserted into an IBM-type binder. In addition, Paradise provides a convenient *Quick Start Manual*, a four-page brochure that contains sufficient information to install the card and get it running. Each of the add-on modules has its own manual.

STB Chauffeur. Chauffeur is unique among the five graphics cards reviewed in that it requires no special software or drivers to reproduce 640-by-200 or 320-

by-200 "color" graphics on a monochrome monitor. Characters are formed in an 8-by-14 box, and screen resolution is 640 by 350. The card has 32KB of display memory, only 16KB of which is used in text mode. Full-screen, high-resolution graphics (640 by 350) are supported with appropriate software; Chauffeur is supplied with drivers for Lotus 1-2-3, Symphony, and Ashton-Tate's Framework. It must be the only video card installed in the system in order to work properly.

STB Chauffeur has a parallel printer port and a nine-pin monitor socket; it can drive an IBM monochrome monitor or equivalent. The printer port can be configured as LPT1, LPT2, or LPT3, or disabled altogether. A battery-operated clock/calendar is the only option that is available.

The card comes with PC Accelerator, a program that provides RAM disk, print spooler, and clock/calendar functions. It also provides keyboard control commands that permit control of the

B*ecause Chauffeur does not require special software, it is by far the quickest and simplest of these graphics cards to install and use.*

print spooler, and a soft system reset that does not erase information in the RAM disk or print spooler.

Two manuals are supplied with Chauffeur. One is for the card and one for the software. They are both punched for insertion into an IBM-size binder. The manuals are clear and straightforward, with installation and configuration instructions that are very easy to follow. Because Chauffeur does not require any special software, it is by far the quickest and simplest of these five graphics cards to install and use.

Tseng Laboratories UltraPAK. Tseng's UltraPAK card has a nine-pin monitor socket and a standard parallel printer socket. This graphics card can drive only an IBM monochrome monitor or equivalent; it has no color capabilities. However, the ColorPAK option card can be added if both color and monochrome monitors are desired. Graphics modes supported with ColorPAK include IBM medium and high resolution, Colorplus, PCjr, and (with a high-resolution color

monitor such as Princeton Graphic's SR-12) 640-by-400 color graphics.

UltraPAK provides 720-by-350 resolution on a monochrome monitor; characters are formed in a 9-by-14 box. The card has 64KB of video memory, which supports multiple pages of text (16 pages) or graphics (2 pages). Two text modes are available: standard 80 column by 25 row, and compressed 132 column by 44 row.

Built into the UltraPAK card are a clock/calendar, a serial port, and a printer port. The UltraPAK can also take one piggyback module: either 64KB-384KB memory or a floppy-disk controller. A second serial port can be added directly on the card, not as a piggyback.

The well-organized UltraPAK manual comes in its own IBM-size binder. It has especially clear information on the software that accompanies the product, as well as on using UltraPAK with a variety of popular programs (Symphony, BASICA, and WordStar). An excellent technical reference section is included.

One problem was encountered when installing the UltraPAK card, which was a consequence of the way various add-on printer ports are configured. The system used to test the cards for this review includes a multifunction card (AST Megaplug) with a printer port treated as LPT1. UltraPAK's printer port, therefore, was configured as LPT2, and the printer was left connected to Megaplug. Printing worked fine under DOS (COPY FILENAME PRN) and a word processor, but not with Lotus 1-2-3.

The problem was that the printer ports of some multifunction boards (AST included) are configured at the hardware address for LPT2 (&H378) under the assumption that the system already has another printer port at the hardware address for LPT1 (&H3BC). If no port exists at address &H3BC, DOS assigns the port at address &H378 as logical device LPT1. If, as in this case, two ports are at address &H378, a potential conflict exists. Depending on how a specific program sends output to the printer, this may or may not cause a problem. Reconfiguring the UltraPAK port to LPT1 solved the problem.

The UltraPAK card is not 100-percent compatible with the CGA in that it requires software to use the BIOS routines for setting graphics modes. Software that writes directly to the video control registers on the CGA will not work properly with UltraPAK. The great majority of programs use the BIOS routines; the few that do not are mostly games. Tseng sells SoftPAK 2 (list price \$99), a half-length expansion card with



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on-board firmware that makes the UltraPAK 100-percent compatible with all color/graphics software and makes set-up programs unnecessary. The disadvantage is that UltraPAK plus SoftPAK 2 require two slots to operate.

UltraPAK comes with a number of utility programs for reading and setting the clock, configuring a RAM disk, and switching between 80- and 132-column text modes. Of particular interest is the 132-by-44 text driver for Lotus 1-2-3. When this driver is installed, every time 1-2-3 is entered from the Lotus access system the user must choose 80-by-25 or 132-by-44 mode. The latter mode is extremely useful when working on large spreadsheets; even though characters are small, they are clear and easily readable. This mode also can be used with WordPerfect 3.0 and WordStar 3.3.

PROGRAM COMPATIBILITY

All of the graphics cards reviewed were given a thorough workout with a variety of programs, including Lotus 1-2-3, dBASE II, WordStar 2000, Perfect Writer, Microsoft Flight Simulator, and the SAMPLES programs supplied with IBM BASIC. Home-written graphics programs in BASIC, Turbo Pascal, and assembly language were also tested (including the routine PLOT.ASM presented in

"Plotting Data," Peter Aitken, *PC Tech Journal*, March 1985, p. 123). All programs worked with all cards with one exception. Flight Simulator was not totally compatible with the Tseng UltraPAK; while the actual flying worked fine, the configuration menu would not appear on the screen when Esc was pressed. This is the result of Flight Sim-

Four out of five of the cards supply the crisp, clear text characters of a monochrome display plus the ability to do graphics with any software.

ulator trying to write directly to the video control registers, which is not allowed by UltraPAK. The SoftPAK 2 accessory card solves the problem.

Four out of five of these graphics cards supply the crisp, clear text characters of a monochrome display plus the ability to do graphics with essentially any software. Everex's Graphics Edge, because it limits graphics displays to 60

percent of the monochrome screen, produces unacceptable results.

Users who must squeeze as many functions as possible into one expansion slot should consider Tseng's UltraPAK or the Paradise Modular Graphics Card. They are essentially identical in terms of the functions they provide in one slot. The UltraPAK has a higher screen resolution and 132-by-44 text; the Paradise card has a lower price and can drive a color monitor.

If extra memory or a serial port on the graphics card is not important, consider Genoa's Spectrum or STB's Chauffeur. Spectrum offers higher resolution, limited 132-by-44 text modes, and color ability; the slightly less expensive Chauffeur offers a clock/calendar (as an option) and is quite simple to use. Any one of these four graphics cards represents a significant step forward in video display for the PC.



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CIRCLE 347 ON READER SERVICE CARD

Peter Aitken is an assistant professor in the physiology department at the Duke University Medical Center in Durham, North Carolina, where he uses IBM PCs extensively in his research. He does freelance computer consulting and programming and has written and marketed a package of laboratory software.

WORKING WITH THE EDGE

Arriving a little too late for a full review, the Everex Edge monochrome/color graphics adapter is nonetheless worthy of note. Any similarity between Everex Edge and Everex Graphics Edge ends with the names: they are entirely different products from the same company.

The Edge emulates the IBM Monochrome Display Adapter and the IBM Color Graphics Adapter without any resident driver software, and is able to emulate the Hercules monochrome graphics board with a bundled driver program. Unlike the Everex Graphics Edge, the Everex Edge displays the high-resolution graphics raster on the IBM Monochrome Display in its proper proportions. Both 44-by-132 and 25-by-132 text modes are available, with included screen drivers for Lotus 1-2-3 and Symphony. The Edge carries 64KB RAM and includes a printer port and light-pen connection.

The Edge is configured for use by way of five jumper blocks on the board. These blocks set the power-up defaults; the utilities that are pro-

vided by Everex allow the user to change any mode or board option after boot-up. Installation instructions are quite good and include a detailed diagram of the board and of the locations of its jumper blocks.

Software need not be well-behaved to operate with the Edge; direct access to 6,845 registers is handled transparently. The documentation provided with the Edge, while not typeset, is complete and well-organized. Technical information on board memory mappings and register assignments is very well presented. As for programming examples, they are given both in BASIC and 8086 assembly language.

At \$399, the Everex Edge is a solid product, priced competitively.

Both the monochrome and color images in the photograph at the beginning of this article were generated by the Everex Edge. The program used to generate the graphics was Telepaint by LCS/Telegraphics of Cambridge, Massachusetts.

—JD

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So with BASIC_C, when you're thinking INPUT, go ahead. Use it. Or LPRINT or LOCATE or INKEY. But without BASIC_C, you will find that every line of code plunges you back in the C texts to figure out how to write it. Someday you'll want to, but for now, BASIC_C will start your programming quickly at the statement level so that you can concentrate on C's larger concepts.

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BASTOC

Translates BASIC to C

You'd like to upgrade C, but what to do with that warehouse of BASIC routines you've carefully polished over the years? And how to face converting your famous Leviathan accounting system from BASIC, much less your Labyrinth file management package?

With BASTOC™ a translator which takes in BASIC source code and emits pure Kernighan & Ritchie C. Our BASTOC understands Microsoft Extended BASIC (except for dynamic dimensioning and common). It will optionally convert your program into a single monolithic C function or will decompose it into separate functions, one for each GOSUB label.

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The newest version of this premier programming tool lets you layer your screen designs with up to ten overlapping images, making it easy to background a screen with pop-up lists, help boxes, and alternate sets of input fields.

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Panel builds in a user interface for key-stroke movement within and between fields, and supplies extensive validation routines for checking user field entries — in source code, so you can tack on your own unique variants.

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RUN/C — THE C INTERPRETER

Now Two Versions for C Rookies or Pros

RUN/C is not just a C interpreter, it's an interpreter that behaves like BASIC! Use RUN/C™'s full-screen, in-line editor to create a program. RUN it, just like BASIC. If it stumbles, just LIST it, EDIT it, add lines, delete lines, RUN it again, fix it again. It has familiar commands like LOAD, MERGE, SAVE, FILES, even TRON — and TRACE to show each time a variable changes, and a built-in profiler to report the number of times each program line is executed.

RUN/C is ideal for rapid program development. Put up code at high speed, tinker and re-arrange, try out things devil-may-care, and let RUN/C find your typos and malaprops. Bang away at tight little sections until they're bullet proof. Then hand them to the big compilers for conversion to linkable modules.

RUN/C has a treasury of functions built into the interpreter — over 100 paralleling the most used functions found in standard compiler libraries. So when and if the time comes to compile, your source code will find counterparts.

RUN/C LITE

RUN/C Lite makes a splendid teacher. The manual has not just instructions how to use RUN/C, but its 500-plus pages provide a thorough-going demonstration of the C language itself. Every feature, of C or RUN/C, is accorded its own micro-chapter. Over 100 of these chapters are devoted to RUN/C's built-in functions, and every one lists a sample program showing how it is used. These same programs are on the disk. So as you read them in the manual, you can run them on the screen, see what they do, discover why they do it. And tamper with them, try things out, see what effects your changes have.

RUN/C Lite utilizes source code only, whether created by its own editor, or from any ASCII file, such as programs you've already written or commercial libraries which supply source code. Moreover, source modules may be held separate and #included (no point replicating PC BASIC's deformities).

Lots more features: system interrupts, a shell command to invoke any operating system command without leaving RUN/C, even the ability to load a preferred editor in parallel and switch back and forth. (Occupies 180k, 256k recommended.)

RUN/C PROFESSIONAL

Sounds great, but if you're a pro, you know that source-only interpreters mean commercial binary tools are off limits.

No longer true, because now there's a new professional version of RUN/C that gives you the power dynamically to load and unload multiple binary function libraries while in its interpreter. Your code can now reach for functions in any of the professional C libraries — C-Food Smorgasbord™, Halo™ Greenleaf™ — any library compiled with Lattice's large model.

The Loadable Libraries™ link-up loads loads of time from development work. Functions once available only after compile and link are at your fingertips at

the front end for instantaneous testing.

Your own function archives? No difference. Compile them into a Lattice large-model binary library, and yours can be set up for RUN/C integration the same way. The manual shows how to interface a library. (Important: you need the Lattice compiler, 320k minimum and 512k recommended to fit libraries.)

RUN/C Pro adds an extra level of debugging aids. They are ingeniously installed behind a built-in function, so you can call for debugging conditionally. The called function either executes any of RUN/C's commands (e.g., LIST) or paints a menu of debugging tools to choose from, including immediate mode to display variables, single-step tracing, and changing of variable values.

The Pro version also enables #define's with macros, and supports standard input-output functions (stdin, stdout, stderr). RUN/C Pro has every feature of RUN/C Lite plus the major infusions cited.

So now RUN/C Professional can tackle projects of any size. Use it as a creative front end to feed a continuous stream of source code into compiled modules — and link to them. Only the source work-in-progress is still interpreted; the finished modules will whiz by at object speeds. It will change how you work. You can bet your living on it.

Version: Code: List: Our Price:
RUN/C Lite S0910 # **\$109** *CALL
RUN/C Professional S0950 # **\$225**

LATTICE C COMPILER

Over 25,000 Users Make it the Best Seller by Far

Lattice C has been the standard-bearer compiler for years. Peter Norton in *PC Magazine* (1/8/85) said, "best for systems programming... light code... total control of what's going on... noticeably better than any of its competitors". After reviewing nine compilers for the PC, the *PC Tech Journal* unequivocally declared Lattice C "best for software development... it compiles fast and produces fast programs."

When Lattice C appeared, there was nothing comparable. Ever since, software developers have created exceptional tools and function libraries to marry into Lattice. Programmers now have an enormous resource of libraries and utilities to speed their work. That's a vital consideration in choosing a compiler. Better check whether the latest geewhiz may have only gewgaws to go with it.

Lattice C runs on virtually any computer using an 8088 or 8086 chip, and generates code which optimizes use of the 8087 chip, if present. Create your source files with any word processor or text editor and Lattice C will compile them into Intel 8086 object module format for linking to other modules by DOS's Link or our Plink86.

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BETTER BASIC

BASIC Gets Serious With This Hefty Implementation

NEW!

If you have several thousand hours of BASIC programming under your wing, what a dilemma the great migration to C poses! Leave all that experience (and code) behind and head for new horizons? Or stay in the nest and become an endangered species?

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BetterBASIC indents automatically for logical, readable listings, and is sated with

statements to encourage structure. Loop structures like FOR, WHILE are treated as sealed-off logical blocks. They safeguard against typical BASIC bedlam by not permitting GOTOs in or out.

BetterBASIC adds the renowned pointers of C. Variables defined as pointers store addresses of other variables of the same type assigned to them, such as arrays or strings. Use pointers to directly load new data into the addresses at much higher speed.

If you know C, you never thought BASIC would ever have structures, but here they are. A structure gathers variables of different types into a record which is given a name. Arrays of such structures may be defined to accommodate data for multiple records. The structure name is all that is needed for file reads and writes, leading to the unannounced demise of FIELD, MKI\$, etc., CVD, etc., LSET, RSET. Are you listening Microsoft users? They, and the Babel of redundant variables they needed are, GONE!

BetterBASIC has "procedures". They take the place of BASIC subroutines. Set up in their own work space and edited separately on the screen, procedures cannot run afoul of main program code. They are summoned by name, not (as in GOSUBs) by line number, and variables declared within them cannot be affected by the main program or other procedures unless deliberately passed back and forth.

Best of all, once you have sturdy procedures which can be relied on never to fail, store them in compiled modules. Have BetterBASIC fold in such modules at load time, so they are generally available to your coding, just like PRINT or INPUT. So what have we here? That's right, an extensible language to which you can add your own commands!

There's lots more than fits here. Ask about a runtime module to build COM and EXE files, and a Btrieve interface.

So... to C or not to C? Well, maybe not. At last it's a real choice.

Product Code: S1200 Our Price:
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MARK WILLIAMS C SYSTEM

Compile With Built In Source Debugging

NEW!

With the usual compiler, your source code disappears down a black hole. If your program doesn't do what you intended, there's no telling what's going on in there. Hey, thanks for turning the lights out!

Mark Williams thinks you shouldn't be marooned in space. Their C Programming System™ expands the universe with a source code level debugger which comes with their compiler, so you can watch your own friendly code, not hexadecimal flotsam, float by a window as it executes, with your program's screen output in another window.

You can set breakpoints to stop execution on source lines or when variables change; log functions called to chart the course your program took; change local variables to test different outcomes.

The compiler itself has long been a

bright star. It is a full K&R implementation and then some, with enumerated and void data types, structure assignments, and Berkeley rules — fully UNIX compatible. It boasts small and large memory models, 8087 support, ROMable code, DOS calls and the fastest compiler library around. Extensive optimization lets this compiler claim the tightest code and fastest execution of all the compiler luminaries, especially with the large model. User comments confirm it, and so do reviewers: "Has the most professional feel of any package we tested," *Byte* (8/83); "Of all the compilers reviewed, ... first choice for product development," *PC World* (8/84).

Product Code: S0150 # Our Price:
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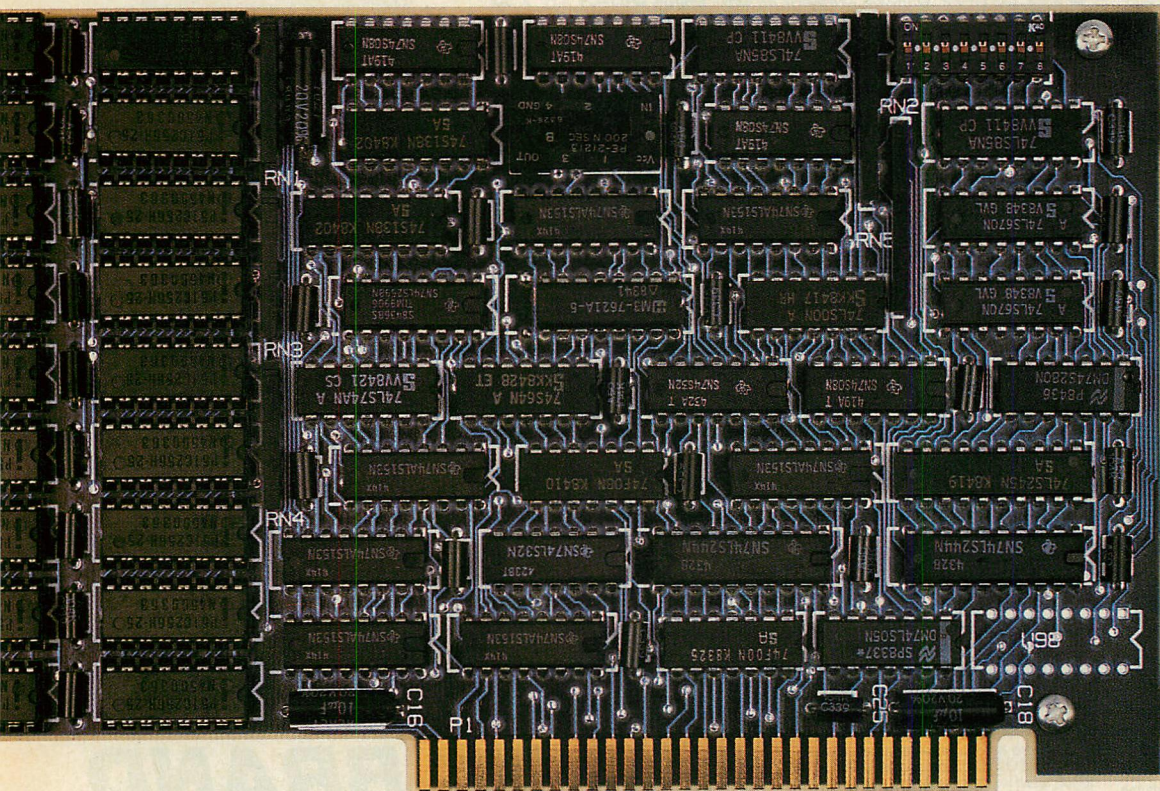
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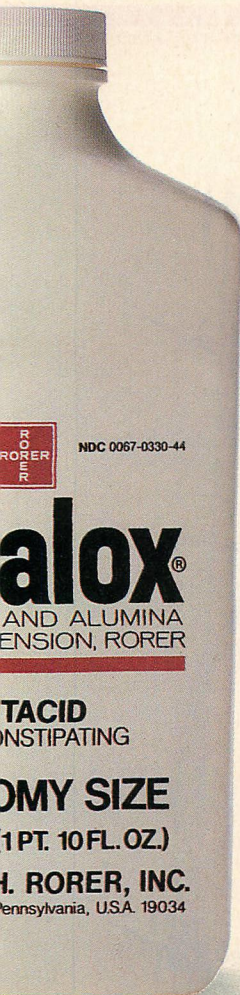
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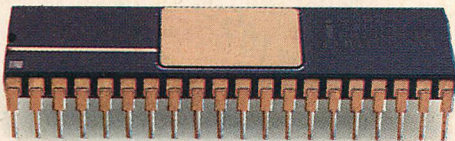
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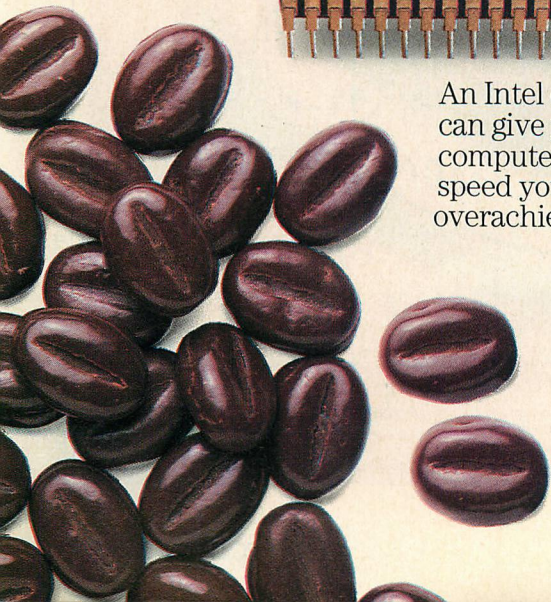
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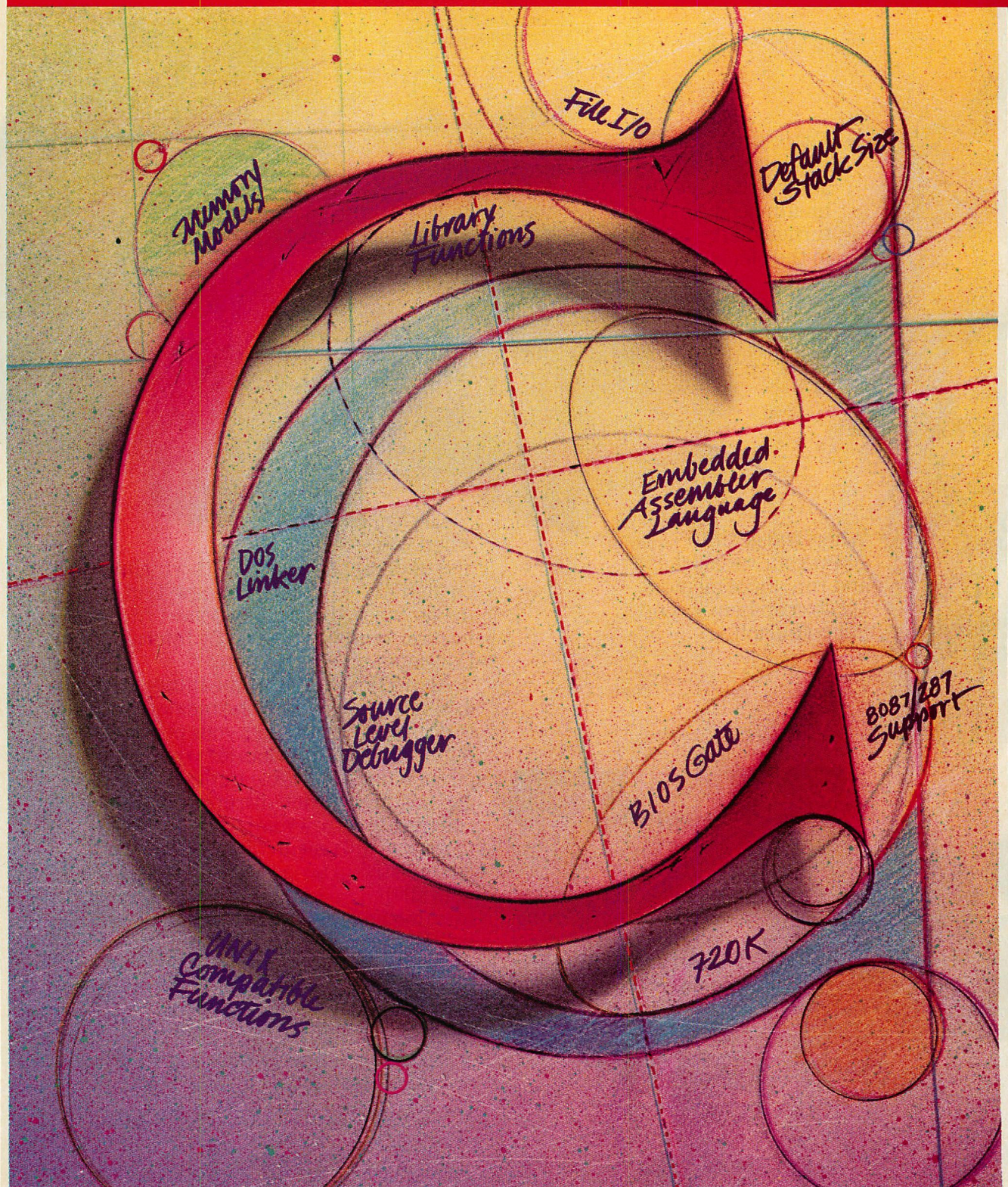


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*Consistently good performances are achieved
in a field of 12 compilers, offering
personal and professional levels of implementation
in this increasingly popular language.*

WILLIAM J. HUNT

The C language has gained much popularity for use in serious software development. In the past few years compiler vendors have been active in updating their products in response; most of the eight compilers reviewed in "C and the PC" (William C. Hunt, November-December 1983, p.110; January 1984, p.91) have improved substantially. In addition, some new contenders have appeared on the scene. The current state of C is surveyed here—the products available and what they offer today's C programmer.

A C compiler should provide tools that make effective use of the contemporary IBM PC environment. Much has happened in two years to change that environment: RAM is cheap and is used in large amounts, and hard disks are common. The PCjr, PC clones, and the PC/AT have broadened the definition of PC compatibility. PC-DOS has been extended greatly with hierarchical directories and network support. How well does this current crop of compilers meet the challenge?

Twelve products are reviewed here. They range from \$50 compilers for personal use to \$500 packages suitable for development of large software products. The basic specifications and the features and options of each is discussed individually and comparatively, and the documentation for each is evaluated for its effectiveness. With the exception of the Toolworks compiler, all the products tested support the full C language and provide all of its standard library functions. Three vendors of DOS C compilers, Telecon Systems, Super-soft, Inc. and Whitesmiths, Ltd. either could not be reached or declined to provide a product for review.

Table 1 lists the basic specifications for the compilers reviewed. The prices shown are vendor list. If price is an important criterion in choosing a compiler, research alternatives before eliminating a product from consideration. Some of the more popular (and expensive) compilers are available at substantial discounts through mail order software dealers, and vendors sometimes offer discounts to students and other special categories of buyers.

All of the compilers operate under MS-DOS or PC-DOS—while they may provide some IBM PC-specific library functions, they will require MS-DOS compatibility only. Some of the products also are available for other environments: versions of the Manx Aztec compiler for the Radio Shack TRS-80, CP/M-80 (8-bit) systems, the Apple II family and Macintosh, and the Commodore 64; the Lattice compiler for the IBM 370 family, Tandem computers, and some Hewlett-Packard computers. Aztec C, Wizard C, and Lattice C are available in cross-compiler versions. The Microsoft C compiler is available for the company's XENIX operating system and can generate .EXE files for the DOS environment.

In the table, the compilers have been rated on the number of special-purpose add-on libraries they support. These libraries are not of equal quality; the rating suggests the likelihood that a given library will be available for a particular compiler. The Microsoft compiler is fairly new; its now limited add-on library support should improve.

The minimum disk space requirement is the amount of space needed to edit, compile, and link C programs in a floppy-disk system. This includes the

compiler, the DOS linker (LINK) or the linker supplied with the product, and the library files needed for a C program using float variables and the small memory model. An additional 300KB was added for the following: 40KB for DOS 2.0, 20KB for DOS commands, 40KB for the screen editor, and 200KB for working space (C source files, .OBJ files, and .EXE files).

The bare minimum disk space is the space required for programs of moderate size to be edited, compiled, linked, and executed without changing floppy disks. The standard IBM PC floppy disk contains 354 KB of file space, so most of these compilers are a tight fit on a system with two floppy-disk drives only. A hard disk or a large RAM disk would be a wise investment for any serious development work.

The minimum RAM figures listed are from the product manuals; memory sizes were rounded up to 64KB. The requirements are quite acceptable; today's inexpensive RAM chips have made 256KB a de facto minimum.

Most of the compilers support the full C language as defined in Kernighan and Ritchie's *C Programming Language* (Prentice-Hall, Inc., 1978). The Eco-C88 compiler does not support bit fields or the `#line` preprocessor directive—a minor, but unnecessary, annoyance. The Toolworks compilers omits the `typedef` keyword, bit fields, data declarations within nested blocks, and arguments in macros (`#define min(a,b) . . .`, for example). Its functions cannot accept a variable number of arguments—a major limitation. In addition, its floating-point arithmetic is limited to 32-bit precision and variables declared as double are represented as 32-bit values.

TABLE 1: Compiler Specifications

	ECO-C88	DATALIGHT	TOOLWORKS	DeSMET	C-SYSTEMS
VENDOR	Ecosoft, Inc.	Datalight	The Software Toolworks	C Ware Corp.	c-systems
VERSION TESTED	2.7	1.06	3.2	2.41	2.08a
SUPPORTED ON OTHER SYSTEMS	CP/M(8)	—	CP/M(8)	Macintosh	—
CROSS-COMPILER HOSTS	—	—	—	—	—
AVAIL. OF ADD-ON LIBRARIES	—	—	—	Good	—
MIN. DISK SPACE REQ. (KB)	709	613	585	482	645
MINIMUM RAM (KB)	256	196	128	128	192
SUPPORTS FULL LANGUAGE	Almost	Yes	No	Yes	Yes
FULL STANDARD LIBRARY	Yes	Yes	Yes	Yes	Yes
PC-SPECIFIC FUNCTIONS^a	Yes	Yes	Yes	Yes	Yes
ASSEMBLY LANG. INTERFACE	Yes	Yes	Yes	Yes	Yes
COMPATIBILITY					
MASM	Yes	Yes	Yes	\$35	Yes
LINK	Yes	Yes	Yes	\$35(same)	Yes
SOURCE CODE					
Start-up sequence	Yes	Yes	Yes	\$25	Yes
Library functions	\$10	Yes	Yes	\$25(same)	\$245
MEMORY MODELS					
Large ^b	—	—	—	—	Yes
Medium ^c	—	—	—	—	\$50
Compact ^d	—	—	—	—	\$50
Small ^e	Yes	Yes	Yes	Yes	Yes
.COM ^f	—	Yes	Yes	—	—
OTHER PROGRAMS INCLUDED					
Librarian	—	—	—	Yes	—
Assembler	—	—	—	Yes	Yes
Linker	—	—	—	Yes	—
Source-level debugger	—	—	—	\$41	Yes
MAKE ^g	Simple	—	—	Simple	—
Other	—	—	Profiler option	Editor, profiler, RAM disk	—

—=No

^a DOS and BIOS gate, port I/O, memory access (peek/poke)^b 1MB code/1MB data^c 1MB code/64KB data^d 64KB code/1MB data^e 64KB code/64KB data^f 64KB code and data combined^g Automates recompilation

All of the compilers support the standard C library; the Computer Innovations and Toolworks libraries, however, have nonstandard I/O functions. Some generic PC-specific library functions are essential to writing useful C programs on the PC: gate functions that generate any software interrupt permit the user to access DOS and BIOS services; port I/O functions let him manipulate the PC's hardware and memory access function and efficiently access and manipulate memory outside the C program. With these functions the user can construct many other specific PC access functions; without them, he is forced to write assembly language functions for each task.

Each of the compilers tested provides an interface to functions written in assembly language. All of them except the Digital Research, Inc. (DRI) product can be used with the IBM/

Microsoft Macro Assembler (MASM) and the DOS LINK. MASM/LINK compatibility was not the normal method of operation for the DeSmet, Manx, and Mark Williams compilers, and it was not well documented for any of the three.

Most of the products include source code for the start-up sequence that sets up the environment required by C functions. This code is modified to use C for device drivers, applications in ROM, and memory-resident applications; it provides vital information about a product's C environment. The code's accessibility illustrates the openness of the C language. The source code for library functions also serves as low-level documentation and may be important in making an application work perfectly. Only the DeSmet compiler does not include source code in its standard library, but the \$25 optional package with start-up source code includes

source files for an alternative library.

The PC's 8088 processor (and the AT's 80286) do not access large amounts of RAM naturally or efficiently. The more expensive compilers support a variety of memory models, which enables the user to tailor the trade-off between memory access and execution speed. The small model produces efficient programs and is fine for small- or medium-sized programs such as utilities. The large memory model provides access to a megabyte of memory and is vital for many applications. (It still limits all static and global data to 64KB.) Other memory models may be useful in specific cases but the small and large models are the minimum required for applications development.

Some of these compilers are packaged with librarians, assemblers, linkers, and debuggers. Librarian programs are necessary for sizable devel-

OPTIMIZING	MICROSOFT	WIZARD	LATTICE	C PROG. SYS.	AZTEC	DRI
Computer Innovations 2.3a	Microsoft Corporation 3.0	Wizard Systems Software 2.1b	Lattice, Inc. Lifeboat Assoc. 3.0b	Mark Williams Company 2.14	Manx Software Systems, Inc. 3.2d	Digital Research 1.1
—	XENIX	—	IBM 370, Tandem	Coherent	See text	CP/M 86
—	XENIX	VAX VMS/UNIX	370, VAX UNIX	—	See text	—
Good	Fair-good	Fair	Very good	Fair	Good	—
720	827	587	645	576	520	593
128	256	256	128	256	—	192
Yes	Yes, struct, ANSI	Yes, struct	Yes, struct, ANSI	Yes, struct	Yes	Yes, struct
Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes	—
Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Option	Option	—
Yes	See text	Yes	Yes	Option	Option	—
Yes	—	Yes	Yes	Yes	Yes	Yes
Yes	—	Yes	\$500	—	Yes	—
Yes	Yes	Yes	Yes	Yes	Yes	Yes
—	Yes	Yes	Yes	—	Yes	Yes
—	Yes	Yes	Yes	—	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	—	Yes	—
Yes	Yes	—	Yes	Yes	Yes	Yes
—	—	—	—	Yes	Yes	Yes
—	Yes	—	—	Yes	Yes	Yes
\$225	—	—	\$175	Yes	Partial	—
—	—	—	\$195	—	Yes	—
—	—	LINT option	—	—	Editor, grep,diff	—

A dollar amount indicates that the feature is available at an additional charge. Some of the more popular (and expensive) products are available at substantial discounts through mail order software dealers.

opment projects and a time saver for personal use. Building a familiar set of functions to supplement the library is recommended in this language; a librarian makes the task painless. (MASM includes a librarian—a good way to obtain one if a compiler is not packaged with such a program.)

The assemblers provided are a mixed blessing: most operate faster than MASM, but none support the full macro assembly language. (They may prove good enough to discourage the purchase of MASM, if a user does not already have a copy, thus saving him about \$150.) The special linkers do not have the same potential for saving a purchase (because LINK.EXE is already included with DOS); however, some offer faster linking times and consume less disk space.

The debuggers by c-systems, Mark Williams, and C Ware (DeSmet) display

the C source code on the screen and allow the user to step through a program and examine and modify variables. Debugging a C program with these tools is like using a screen-oriented editor. The Manx Aztec debugger is an assembly language debugger with limited access to names of C functions and variables. A debugger with partial source-level debugging capability is available for an additional cost with Lattice C. The Computer Innovations compiler also offers a separate debugger.

Several of the packages provide a facility like the UNIX MAKE program for recompiling source files. The simpler versions compare the file date and time of source and .OBJ files, recompiling only if the source file is newer than the .OBJ files. The Aztec and Lattice MAKE programs are more elaborate. The DeSmet and Aztec products contain other tools, including screen editors.

IMPLEMENTING THE LANGUAGE

Table 2 lists additional features that might be included by a good C compiler and indicates the degree of support offered by each of the products. **Compiling and linking.** Effective compilation features can make the development task go much faster and easier. All of these compilers use more than one program to compile a C source file, but regardless of how many steps are needed, a single command should trigger the entire compilation. Some provide batch files to automate execution of the individual steps, while others offer a driver program that invokes the individual passes needed. The Datalight compiler includes neither a batch file nor a driver program; however, its documentation describes the construction of a suitable batch file.

Some of the products accept lists or file specifications, including the DOS

TABLE 2: *Compiler Features*

	ECO-C88	DATALIGHT	TOOLWORKS	DeSMET	C-SYSTEMS	OPTIMIZING	MICROSOFT	WIZARD	LATTICE	C PROG. SYS.	AZTEC	DRI
COMPILER OPERATION												
Single-step compile command	Yes	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Compile and link	Yes	—	—	—	Txt	—	Yes	Yes	—	Yes	Yes	—
Accepts list of files	Yes	—	—	—	Yes	—	Yes	Yes	Yes	Yes	—	—
Accepts wild cards	—	—	—	—	—	—	Yes	Yes	Yes	Yes	—	—
Lists preprocessor output	Yes	Yes	—	—	Yes	Yes	Yes	Yes	Yes	Yes	—	Yes
Lists assembler output	Yes	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Line numbers in err. msgs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Header file search list	Yes	Yes	Yes	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flexible disk file layout	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—
C LANGUAGE EXTENSIONS												
Embedded assembly language	—	—	—	Yes	Yes	—	—	Yes	—	Yes	Yes	—
Void function returns	Yes	Yes	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes
Enumerated types	Yes	Yes	—	—	—	—	Yes	Yes	Yes	Yes	—	—
Structure assignment, etc.	—	—	—	—	—	—	Yes	Yes	Yes	Yes	—	Yes
Function argument checking	—	—	—	—	—	—	Yes	Txt	Yes	—	—	—
LIBRARY EXTENSIONS												
Math functions (sq. root, exp, log, sin, etc.)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Unbuffered file I/O (read/write)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Keyboard input (low-level)	Par	—	Yes	Yes	—	Yes	Yes	Yes	Yes	Par	Yes	—
PC screen output (cursor control, attributes, scroll)	Yes	—	—	Yes	Yes	Yes	—	Yes	—	—	Yes	—
Execute programs/DOS (exec/fork and system)	Yes	Yes	Yes	Yes	E	Yes	Yes	Yes	Yes	Yes	Yes	—
MS-DOS services (date, time, scan directory, etc.)	S	—	—	S	Few	M	S	M	M	—	S	—
PC-Specific Functions (BIOS, PC hardware)	S	—	—	S	—	M	Few	M	S	—	S	—
UNIX compatible functions	—	—	—	—	—	—	Yes	Yes	Yes	—	Few	—
Error recovery (setjmp, signal, Ctrl-Break, critical error)	Par	—	Par	Par	Par	All	All	All	All	—	—	Par
FILE I/O												
Redirection	Yes	Yes	Yes	Txt	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Full path names	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—
DOS 1.1 support	Yes	—	Yes	Yes	Yes	Yes	—	—	Yes	Yes	Yes	Yes
DOS 3.1 file sharing	—	—	—	—	—	—	Yes	Yes	Yes	—	—	—
Record locking	—	—	—	—	—	—	Yes	—	Yes	—	—	—
ASCII/binary mode	Yes	Yes	Yes	Par	Yes	Yes	Yes	Yes	Yes	Yes	Par	Yes
MEMORY USAGE												
Overlays	—	—	—	Yes	—	—	Yes	—	—	—	Txt	Yes
Default stack size	Max	Max	Max	Max	Max	Max	Sml	Max	Sml	Sml	Txt	Max
Stack size settable	Yes	Yes	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stack overflow checking	—	Yes	Yes	—	—	Yes	Yes	Yes	Yes	—	—	—
8086 FAMILY SUPPORT												
Byte/word alignment	—	—	—	—	—	—	Yes	Yes	Yes	—	—	—
80186/286 support	—	—	—	—	—	Yes	Yes	Yes	Yes	—	Yes	—
8087/80287 support	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Automatic sensing	Yes	Yes	—	—	Yes	—	Yes	Yes	Yes	—	Yes	—
ROM support	—	—	—	—	—	Txt	—	Txt	—	Txt	G	—

—=No E=Execute G=Good M=Many Par=Partial S=Some Sml=Small Txt=See text

A full-featured compiler simplifies the edit-compile-execute sequence and makes the full PC environment available.

wild card characters (? and *), for files to be compiled. These features are great time savers when a number of source files are designated for compilation. Some also support compiling and linking with a single command. This is a handy feature for programs of one or two source files, but can become a drawback; even with more compiling options and increased complexity in the single-command sequences, this method reduces flexibility. For example, none of the compilers permits specifying additional libraries (either add-on libraries such as those reviewed in "Drop-in Modules for C," William J. Hunt, June 1985, p. 100; July 1985, p. 135; August 1985, p. 141, or user-created libraries.) C-systems includes a compile-and-link driver program, but no documentation to go along with it.

The ability to specify a list of sub-directories to search for header (#include) files is a real convenience for users with a hard disk. It is also helpful to be able to place compiler files and libraries to make full use of available system resources (such as a RAM disk or a second hard disk.)

C language extensions. Some of the compilers reviewed support extensions to the standard C language. Several allow embedded assembly language statements in C source files, but few of these provide complete documentation of how the embedded statements interface to the surrounding C functions.

The ANSI C standard will not be complete and made official for some time; however, the Lattice and Microsoft compilers already support the function argument type checking feature introduced by the proposed standard. The method is called *function prototyping*: the programmer specifies argument type in the function declaration and the compiler checks arguments. The following C source fragments show a function prototype declaration and some of the errors that it can detect:

```
int myfun ( long ); /* declaration includes
arg type */
...
i = myfun ( ); /* wrong
number of args */
i = myfun( & i ); /* wrong type */
i = myfun(1); /* automatic conversion
to long */
```

Function prototyping is a major improvement to C; it should be supported by most C compilers once it is made official as part of the ANSI standard.

The Wizard compiler's LINT option finds errors in function calls by different means. LINT checks for discrepan-

cies in usage of functions and variables between C source files. In practice, LINT detects a number of errors correctly but produces some spurious error messages. The Wizard manual describes the options, but the single example of invoking it is incorrect.

Library extensions. Extensions to the standard C library are more useful than extensions to the language; some of the categories are listed in table 2. The most important extensions are the unbuffered I/O functions: **open**, **creat**, **read**, **write**, **lseek**, **close**. Originally these functions were defined to use the low-level I/O services of UNIX; however, they provide capabilities that are essential to many applications.

Interactive applications often require low-level console I/O functions for full access to keyboard and screen capabilities. For keyboard input, the library should provide unbuffered access to a single keystroke (no waiting for a carriage return). These functions should pass non-ASCII keystrokes, such as function keys and cursor control keys, and should not echo characters to the screen. A companion function to check for keyboard input without waiting is also a necessity. For console output, library functions that sense and set the cursor position, scroll or clear the screen contents, and control display attributes (underlining and reverse video) are desirable. Many add-on libraries provide these extended console I/O functions at extra cost.

Many of the compilers reviewed here provide functions to execute either another program (**exec**) or a DOS command (**system**) from within a C program. The c-systems compiler provides only the **exec** program.

DOS provides a number of services that are useful in C programs. For example, setting and returning the default drive and the current directory, creating and destroying files and subdirectories, and searching directories for files matching a specification. The compilers have been rated (in table 2) on the number of DOS services for which the library provides access functions. (The user can write most of these functions in C using the general DOS/BIOS gate function most compilers provide. The library functions for individual DOS services save the time and effort required to decipher the documentation for these function calls in the *DOS Technical Reference Manual*.)

(Some of these libraries provide analogs to system-specific functions from the libraries of UNIX C compilers. These features may be an advantage to

the user who works in UNIX in the IBM PC hardware environment, or who has a number of UNIX-specific C programs. For the user with no investment in UNIX C, such functions will be less useful than straightforward implementations of DOS services.)

Good applications programs need robust error-recovery support. Some libraries provided **setjmp** and **longjmp** functions to set up global exits from errors that occur several function levels deep within a program. A few compilers provide error-handling for Ctrl-Break and critical error exceptions.

File I/O. DOS 2.0 and later provide redirections of standard input and output from the console to files. All of the compilers except DeSmet provide an equivalent service when programs are run under DOS 1.1. The DeSmet compiler implements **getchar** as a low-level function unusable with redirected input. This implementation causes some problems: it does not recognize end-of-file and it echoes input characters to the standard output stream, making it necessary to rewrite existing C programs (filters) that are used with I/O redirection. This problem can be solved by redefining **getchar** with a macro:

```
#define getchar() getc(stdin)
```

DOS 2.0 also introduced subdirectories and long file names that included subdirectory paths. All the compilers except DRI's support paths in library function calls such as **fopen**, **open**, and **creat**. Most could generate programs that ran under either DOS 2.0 or DOS 1.1; a few currently support the DOS 3.1 extensions for file sharing and record locking (important to multiuser and network applications).

Most of the compilers provide a text or ASCII mode in which the end-of-line and end-of-data conventions of DOS text files are converted automatically to match UNIX conventions. This conversion reduces performance and is useful only for sequential reading and writing of simple text files; however, ASCII mode does permit the running of existing C programs. The partial ASCII mode support offered by the Aztec and DeSmet compilers will require the revision of some existing C programs.

The compilers all provide a binary mode with no conversions. This is the mode recommended for use with serious applications as well as with any application where files contain data other than ASCII characters.

Memory usage. Several of the compilers provide overlay support so that programs larger than available memory can

TABLE 3: Documentation Quality

	ECO-C88	DATALIGHT	TOOLWORKS	DeSMET	C-SYSTEMS	OPTIMIZING	MICROSOFT	WIZARD	LATTICE	C PROG. SYS.	AZTEC	DRI
INSTALLATION												
Packing list	—	Yes	Yes	Yes	—	—	Yes	Yes	Yes	Yes	Yes	Yes
File inventory	Yes	Yes	Yes	Yes	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Key files described	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	Yes	Yes	Yes	Yes
Quick step-by-step procedure	Yes	—	Txt	—	Fl	Yes	—	—	Yes	Yes	Yes	—
Instructions for floppy and hard disk configurations	Yes	—	—	—	—	—	Yes	—	Yes	Yes	Fl	—
List changes from last version	Yes	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SETUP												
Setup assumptions described	Txt	—	—	G	P	P	F-G	F-G	F-G	F-G	P	P
Notes on RAM/second hard disk	—	—	—	F	—	F	—	G	F	—	—	—
OPERATIONS EXPLAINED												
Compile options	F	G	F	G	F	G	F	F	G	F-G	F	G
Compiler error messages	P	F	G	F	G	G	G	F	G	—	G	G
Linking C programs	P	G	—	G	F	—	G	F	G	F	G	P
Runtime error messages	—	G	—	—	—	P	G	—	P	—	G	—
Runtime options	—	G	—	P	F	P	G	F	G	P	F	P
LANGUAGE/LIBRARY SPECIFICATIONS												
Deviations from Kernighan and Ritchie definition	—	G	G	G	G	F	F	F	G	G	F	G
Data type representation	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	F	G	G
Memory models and memory layout	—	F	G	F	G	F	G	P	VG	P	VG	G
DOS and PC-specific features	—	—	F	—	G	G	G	G	G	P	F	P
ASSEMBLY LANGUAGE INTERFACE												
Segment, group, and class specification	—	Yes	Yes	—	G	F	F	G	Txt	P	G	P
Standard prologue, epilogue	Yes	—	—	Yes	G	—	G	P	—	P	F	G
Instruction formats for args, public, extern, struct	—	Ex	Par	Par	Par	—	Arg	Par	G	—	G	VP
Return value conventions	Yes	Yes	Yes	Yes	G	F	G	G	G	F	G	G
Complete examples	—	VG	G	—	G	OD	P	—	G	G	G	—
FILE I/O												
Redirection	—	—	Yes	—	Yes	Yes	Yes	Yes	Yes	—	F	F
Console I/O	—	—	—	—	Yes	Yes	Yes	—	G	—	F	P
Device I/O	—	—	—	—	Yes	Yes	F	—	G	—	F	F
Buffered versus unbuffered	—	Yes	—	Yes	Yes	Yes	G	—	G	F	G	P
ASCII versus binary modes	—	F	F	—	Yes	G	G	F	F-G	P	P	—
LIBRARY DOCUMENTATION												
Average lines per function	7	7	9	11	13	50	20	35	35	20	35	25
Cross-reference information	—	—	—	—	F	G	F	F	G	F	F	—
Functions in table of contents	Txt	Lst	—	—	—	G	Txt	Txt	Yes	F	Txt	—
Examples of use	—	—	—	—	—	G	F	—	—	—	F-G	—
MANUAL ORGANIZATION												
Detailed table of contents	F	G	P	F	P	G	F	F-G	F-G	F	F-G	F-G
Index with functional entries	—	G	P	—	F	VG	VG	P	G	VP	—	G
Order of function documentation	AB	AB	Sec	Sec	AB	AB	AB	AB	AB	AB	Sec	AB
OVERALL RATING	P-F	P-F	P-F	P-F	P-F	F-G	F-G	F	F-G	F	F	P-F
—=No AB=Alphabetical Ex=Example F=Fair Fl=Floppy G=Good Lst=Listed OD=On disk P=Poor Par=Partial Sec=Sections Txt=Text V=Very												

Multi-faceted C packages require good documentation; however, few of these products offer complete and accurate information.

be executed. A number of the compilers can be used with the Plink-86 linker by Phoenix Associates.

When a C program is executed, it must be laid out in memory so that the 8088 stack has room for local variables, function arguments, and return addresses. Some C compilers generate programs that automatically place the stack to allow maximum growth within the amount of memory available. This is convenient for casual programming because the user does not have to worry about the amount of memory needed for the stack. Other compilers select a small stack size as a default; this is convenient when another program is executed from within a C program because it provides a maximum of memory for the program that is executed. In either case, the compiler should provide a mechanism for overriding the default stack size. The Aztec compiler lets the user choose either a small fixed stack or a maximum-size stack as the default. Some C compilers provide an option to detect stack overflow errors, which is useful for catching programming bugs.

8086 processor support. Members of the 8086 family execute the same instruction set, but differences among them affect performance. The 8086 processor in some PC compatibles executes faster if data variables are aligned on word boundaries. However, some data structures defined by DOS or by other programs may require byte alignment of members of C structures. The compilers that provide an option to control alignment are indicated in table 2.

The 80186/286 processors support a few extra instructions beyond the 8086/88 set. Some of the compilers provide options to generate programs using this extended 80186/286 set. These extra instructions do not provide major benefits; further, programs that use them cannot be executed on ordinary PCs. It is much more important to be able to access the 8087 or 80287 math coprocessors. Most of the compilers can generate programs that, although they do not require the 8087, can detect its presence and use it.

Most of the products generate C code executable from ROM. Creating this code requires considerable technical information about how the compiler handles the code. Wizard and Mark Williams provide minimal information, but the Manx Aztec compiler includes a step-by-step procedure and a utility for converting .EXE files into Intel hex format. Computer Innovations provides Rompak, a separate product that generates ROM code.

QUALITY ASSISTANCE

Many features of even a good compiler are difficult to use without good documentation. Table 3 rates the material supplied with each package. The various categories parallel the features already discussed; the ratings describe effectiveness. Substantial differences in quality were quite evident.

Installation. Good documentation should make it easy to install the compiler and verify that it is working properly. A packing list and a list of files on the distribution disks should be enclosed. The manual should offer a concise, easy-to-follow procedure for installation and discuss variations for hard-disk and floppy-disk-based systems. Changes from a previous version should be listed to help the user update.

Setup. The manual's assumed layout of compiler files and user source files on disk drives should be described. The material also should discuss adapting the compiler operation for a different file layout. Most of the manuals are written to the user who has an understanding of DOS mechanisms such as subdirectories, the CONFIG.SYS file, and PATH and SET (environment) commands. A few discussed using a RAM disk for faster compile times.

Operation. Just as important as the number of compiling options offered is the quality of the written support provided for those options. This varied greatly among the group. For example, the Wizard and Microsoft compilers give the user a large number of options, but the organization of their descriptions can stand improvement (both products, however, do provide a separate quick-reference list that is helpful.)

The DOS manual provides some explanation of using the LINK program, but C compiler manuals must describe how C programs are linked—which library files are needed, the ordering of files, and which linker options are required. Of course, packages that include an assembler or linker must include documentation for these programs. The use of the DRI assembler and linker with the DRI C compiler, for example, was not well documented.

Most of the manuals list compiler error messages with explanations. A lesser number provide clarification of runtime error messages produced by compiled C programs; most include some discussion of runtime options such as stack size and I/O redirection.

Language and library specifications.

Although the Kernighan and Ritchie description of the C language is somewhat out of date, a list of deviations

from its specification still is an excellent way to characterize a compiler's implementation of C; many of the manuals included this information.

Nearly all of the compilers provide a list of the size of each C data type. However, descriptions of memory models supported ranged from a sentence or two to a page per model with accompanying diagrams. A compiler manual is the only source of information about memory models and layout, therefore adequate documentation is vital. In the same way, this manual is the only source of information on the compiler's DOS- and IBM PC-specific features and how the library implementation is affected by these.

Assembly language interface. Using a few assembly language functions often is the key to good performance for a C application. Without sound documentation of the assembly language interface, however, this technique is not feasible. Table 3 lists specific topics that should be discussed. The segment, group, and class statement required in an assembly language source file are controlled by the compiler writer; no amount of logic or familiarity with the IBM PC environment can replace documentation of what the compiler requires. Most of the manuals describe how function arguments are passed on the 8088 stack; the better manuals provide details on using arguments, public and external variables, and pointers in assembly language functions. Complete assembly language source files with explanations make the interface documentation much more understandable.

Most of the discussions of assembly language interface demand a proficiency in that language from the user. Look to the better manuals for a more extensive discussion of 8088 architecture and assembly language.

File I/O. Redirection of standard I/O from the console to files is covered in most manuals. Details on console I/O—how the library functions are implemented and how to use the lower level (nonstandard) functions—are important topics. Using library functions to communicate with devices (printers and communications ports) is significant.

Buffered and unbuffered I/O functions—how they differ, when to use each, and how they are implemented—should be discussed, as should ASCII and binary modes in file I/O and how they are invoked.

Library documentation. The description of individual library functions is the largest section in most of these manuals, but the amount of information for each

TABLE 4: Performance Benchmarks

	ECO-C88	DATALIGHT	TOOLWORKS	DeSMET	C-SYSTEMS
COMPILE TIMES (Hard/floppy disk)					
60-line file	18.6/34.7	9.4/20.8	18.1/24.4	11.2/16.8	29.2/45.0
150-line file	35.2/52.6	18.4/31.5	38.5/45.6	16.1/27.6	63.3/96.0
500-line file	57.4/78.9	35.1/49.3	61.1/82.8	25.9/39.3	129.2/160.0
COMPILE TIMES WITH SYNTAX ERRORS (Time/messages generated)					
1 error	18.6/1	11.9/1	42.4/1	4.6/2	30.4/1
4 errors	14.3/1	7.4/5	16.3/10	6.4/6	39.0/28
5 errors	6.0/1	6.8/5	15.5/10	5.8/4	40.9/35
LINK TIMES (Hard/floppy disk)					
1 object file	22.5/56.1	13.1/38.4	30.0/82.8	9.5/24.6	23.7/66.8
6 object files	28.1/66.8	16.2/43.4	33.4/87.6	10.3/28.0	27.6/73.0
PROGRAM SIZES (bytes)					
Eratosthenes sieve	10,714	9,316	10,660	11,776	24,118
No I/O	1,120	2,516	6,234	2,048	12,180
Pentathlon program	12,586	13,556	21,708	16,384	25,268
GENERAL OPERATIONS^a (Small/large model)					
Function calls (Fibonacci)	22.7/—	21.8/—	24.7/—	23.1/—	30.4/34.0
Integer arithmetic	39.2/—	30.4/—	46.4/—	38.8/—	47.6/47.6
Long arithmetic	296.8/—	119.4/—	325.1/—	123.1/—	335.9/360.3
Subscripts (char count)	33.8/—	30.3/—	43.2/—	30.3/—	39.6/46.7
Pointer use (string copy)	43.6/—	38.3/—	81.5/—	41.1/—	50.7/61.6
With register variables	43.6/—	38.4/—	49.9/—	41.0/—	31.2/61.7
Eratosthenes sieve	24.8/—	21.0/—	71.0/—	23.3/—	35.0/41.6
With register variables	24.8/—	21.8/—	30.9/—	23.3/—	29.6/36.2
FILE I/O (Small/large model)					
Read/write ^b					
Floppy disk to floppy disk	6.5/—	6.5/—	6.6/—	6.5/—	6.5/6.5
Hard disk to hard disk	2.6/—	2.5/—	2.8/—	2.5/—	2.8/3.3
Getc/putc ^c					
Floppy disk to floppy disk	73.9/—	24.0/—	86.3/—	66.4/—	85.4/97.4
Hard disk to hard disk	55.4/—	16.9/—	71.0/—	44.7/—	64.5/78.8
Floating-point operations (Software/8087 chip)					
Add/multiply (dot product) ^a	74.2/12.8	89.1/16.0	16.0/7.5	51.6/5.3	55.9/6.8
Exp/log ^d	100.7/5.2	67.0/10.7	18.0/8.3	49.3/1.0	44.4/43.2
Sin/tan (trig functions) ^d	199.0/8.3	70.9/11.6	31.5/15.4	57.4/7.3	38.5/37.4

All times in seconds.

— means that the compiler does not offer this memory model.

^a 20 iterations^b 1 iteration^c 2 iterations^d 10 iterations

function (or closely related set of functions) varies. Some cross-reference related functions. The Lattice C manual identifies DOS function codes found in many PC-specific functions (rendering them far more useable).

Concrete examples are especially helpful; the Computer Innovations manual was the best in this respect. Also, it is convenient to refer to a single-line description of each function in the table of contents; the Microsoft manual provides a list of functions by topic.

Organization. The manuals are a weak feature for all of these products. Their major downfall is that they simply list compiler options and catalog features.

They assume the reader understands the C language (and C compilers), 8088 architecture and assembly language, and DOS details, and further, that he can guess how these all fit together. Information is not arranged to satisfy practical questions from users who do not share the vocabulary or level of experience of the compiler writer. These manuals do not address the needs of applications-oriented programmers whose experience with C and system programming on the PC is limited.

A number of them have useful, detailed tables of contents. Several include alphabetical indexes, but few of these contain practical, functional entries. It is

easier to use an index that arranges the functions in alphabetical order instead of by category (standard library versus PC-specific, for example.)

Only the Microsoft and DRI packages include C language references. This exclusion is not a major fault; many good primers and reference books are available. However, the addition of a reference with the documentation is a nice added convenience.

MEASURING UP

Table 4 presents benchmark results, including tests that measure product efficiency as a development tool (compile and link) and the usefulness of its com-

OPTIMIZING	MICROSOFT	WIZARD	LATTICE	C PROG. SYS.	AZTEC	DRI
31.5/48.9	23.9/47.0	17.0/33.3	15.5/34.6	16.7/28.0	15.0/33.0	19.6/34.6
50.7/72.4	50.0/82.0	26.0/45.0	31.8/56.9	33.7/51.2	38.5/59.3	39.3/54.4
82.3/110.8	84.3/122.3	41.7/68.6	51.0/93.0	53.8/82.4	65.8/93.0	62.1/83.9
20.0/3	27.7/25+	18.7/5	15.6/1	13.6/1	16.9/2	57.7/9
12.2/1	21.5/25+	23.9/18	19.8/20+	16.0/25+	10.3/5	46.9/10
13.7/15	25.1/25+	22.1/20	21.1/20+	16.4/25+	8.4/5	29.7/10
25.1/52.8	16.9/54.4	14.9/38.6	19.7/58.5	39.0/78.2	13.2/45.1	46.5/86.1
29.0/62.7	31.2/100.3	20.4/48.6	24.1/66.9	45.3/86.0	16.1/52.1	49.2/87.6
11,946	8,328	11,968	8,460	12,183	10,080	23,808
4,462	2,056	892	2,680	4,919	2,000	12,928
13,243	22,976	14,150	14,608	15,480	11,344	25,088
23.6/27.3	25.6/29.3	23.6/26.6	24.9/27.9	27.5/31.2	24.2/28.2	22.6/26.3
37.6/37.6	36.7/36.7	38.2/38.2	31.1/31.1	35.8/37.6	35.0/34.6	41.3/41.4
215.9/218.4	110.4/115.2	181.0/184.8	74.0/76.4	192.7/209.8	78.5/79.4	647.0/719.1
32.8/57.8	19.9/23.8	27.6/29.6	28.4/36.1	27.1/30.9	24.8/BUG	26.9/42.0
38.6/44.6	36.5/43.0	36.5/43.0	36.5/46.0	36.6/42.4	38.4/46.0	46.0/202.4
38.6/44.6	13.8/43.1	17.3/43.1	36.5/46.0	30.9/42.4	19.1/46.2	27.8/202.6
27.1/44.3	26.3/22.0	24.3/26.5	21.0/21.0	23.3/27.1	21.5/21.9	23.6/32.5
27.1/44.2	16.2/16.3	17.5/43.1	21.0/21.0	17.7/21.4	17.6/17.8	18.7/27.5
7.0/7.6	6.6/6.8	7.5/6.6	6.5/6.6	6.8/6.6	9.0/6.6	6.5/6.6
3.0/3.7	2.6/3.2	3.2/3.2	2.4/2.8	2.9/3.2	2.9/2.5	2.6/3.5
39.4/31.7	51.3/51.4	62.2/74.4	62.2/62.2	62.2/62.2	39.3/47.7	62.6/98.1
25.0/26.6	26.3/44.3	53.2/63.5	34.6/45.2	41.6/52.9	23.5/27.4	40.2/96.1
78.9/3.0	51.4/3.6	48.8/19.6	95.3/19.1	29.0/3.5	36.2/6.5	52.2/3.3
112.5/1.4	47.0/1.5	62.2/24.4	73.3/1.7	33.7/5.3	52.7/9.4	40.4/39.4
94.3/1.7	59.6/1.9	61.5/18.8	61.7/2.2	40.1/5.5	62.4/12.0	36.3/35.3

These benchmarks measure each product's efficiency as a development tool (to compile and link) as well as the size and speed of the compiled programs that it produces (execution).

piled programs (execution). Most tests were run on a PC/XT with 640KB of RAM and two IBM 10MB hard disks. The floppy-disk system compile and link tests and tests using the 8087 coprocessor were run on a PC with 544KB of RAM and two floppy disks.

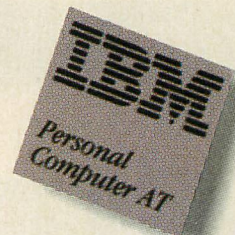
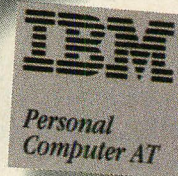
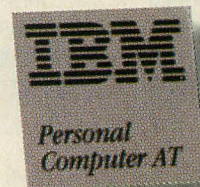
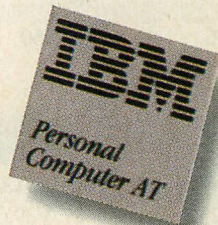
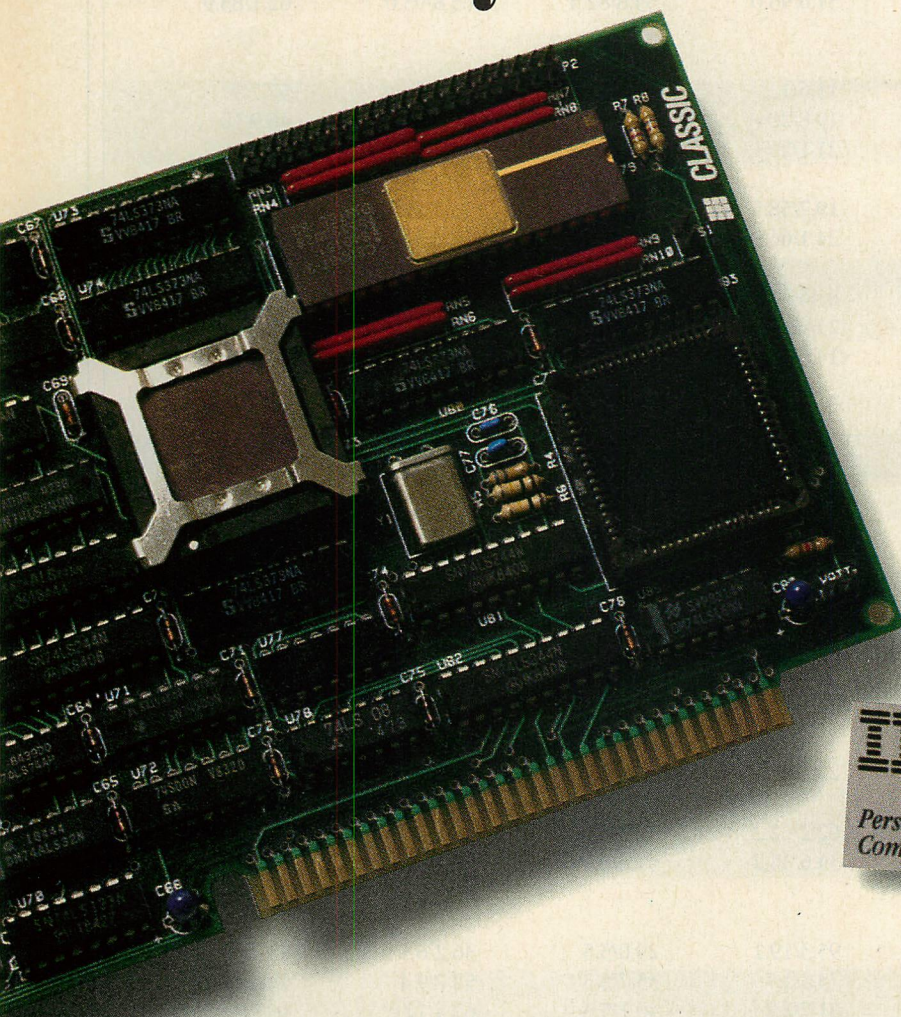
CONFIG.SYS contained the lines FILES=20 and BUFFERS=20 for all tests. The Chkdsk program reported 271,000 bytes of free memory—a RAM disk and a RAM-based spooler program taking up the remainder of memory. The BIOS time-of-day software interrupt (1AH) was used for timing program execution, providing a resolution of 1/18 second. The DOS TIME command pro-

vided similar resolution for compile and link benchmarks. Times are rounded to 0.1 second.

To make the time as true as possible, an effort was made to place compiler and data files in the same locations on the hard disk for each compiler. Differences of less than 2 seconds in compile and link times should be disregarded (a difference of this size can be attributed to differences in a compiler's number of files, their sizes, and its installation process). The placement of data files can be controlled more closely, therefore differences of more than 0.2 second are significant in file I/O. To reduce the effects of cach-

ing by DOS, the file I/O benchmarks were run alternately on floppy-disk drives and hard disks to flush the DOS buffers. Differences of more than 0.2 second also are significant in the execution benchmarks not involving file I/O. **Compile and link times.** Table 4 shows results for source files of approximately 60 lines (listing 1, SIEVE.C), 150 lines (listing 2, PENTATH.C), and 500 lines (listing 3, VIEW.C). All of the listings for this article are available on PCTECH line. The smaller files include the stdio.h header files; the 500-line source file includes three additional header files. Two times are reported for each compiler and source file: a value with

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all files on a hard disk followed by a value with all files on a system with two 360KB floppy disks. In this benchmark, the DeSmet compiler is much faster than the others; the Datalight and Wizard compilers are above average. The c-systems compiler is the slowest, and the Microsoft and Computer Innovations products are slower than average. The source files used in this first test contained no syntax errors.

The second test lists compile times for a 150-line source file with one or more syntax errors. The first file contains one error (a semicolon is omitted). Four syntax errors are present in the second file and five in the last file, including missing comment delimiters (*) and missing ending quotes. The time (for a hard-disk-based system) is followed by the number of error messages. The source files with multiple errors generated an avalanche of error messages from many compilers; however, the Microsoft C compiler was unique in producing more than a screen full of error messages when a single semicolon is omitted.

The times for linking a program with one object file and another with six are reported. Again, values are given for the hard-disk followed by those for the floppy-disk system. Because DOS LINK is used with several of these compilers, some of the times are quite similar. The DeSmet linker has the best times by a wide margin; however, the Datalight and Manx times are better than average. The DRI and Mark Williams linkers are slower than average.

Program sizes. These program sizes (.EXE files) measure how well the library functions are programmed and how well they are arranged into modules. The results are not an indication of the overall effectiveness of the compilers in generating compact code.

The first figure is the size for the sieve program. The second figure is the sieve program with all I/O function calls removed—no `printf` or `scanf`. (Some compilers provide an easy way to exclude the floating-point support normally required for `printf` and `scanf`; in those cases, the figures shown are the file sizes when floating-point support is excluded from the .EXE file.) The third figure is the size of the pentathlon program. All of these files were produced with the small memory model.

The c-systems, DRI, and Software Toolworks products all produce large .EXE files even when no I/O functions are used. Differences in the file sizes produced by the other compilers are not very significant.

Execution times. Table 4 also presents benchmarks for program execution speed. A time is given for the small memory model, followed by a time for the large memory model (if the compiler supports that model). For the floating-point tests, results are given using software and the 8087 coprocessor.

The first test (the Fibonacci test—see listing 4, FIB.C) measures the overhead of function calls; it contains no file I/O and no floating-point operations. A good C programming style requires widespread use of function calls to make programs modular and testable, therefore this test is singularly important. The Toolworks compiler produces the best times here with a number of compilers close behind.

The next two tests measure the speed of a mixture of operations on integer and long integer data (see listings 5 and 6, INTEGER.C and LONGINT.C, respectively). A few multiply, divide, shift, and bitwise and/or op-

The benchmark results for file I/O are nearly identical for all of the compilers tested, indicating that these products make efficient use of DOS I/O calls.

erations are mixed with a number of add and subtract operations. Datalight is the fastest in integer arithmetic for the small model. Lattice C is fastest in long integer for operations; only Manx C is close. (The results vary more for this benchmark than for any other benchmark that was performed.)

The subscript test counts the occurrence of characters in a 500-character string and uses register variables for integers. The Aztec compiler hung when compiling these functions with the large model. The string copy test uses pointers that are incremented to copy a long string. Times for the Eratosthenes sieve benchmark (see listing 7, PENTATH2.C) also are given. Both the pointer string copy and sieve benchmarks were run with and without register variables.

These tests illustrate the effects of register variable declarations. Several compilers use register variable declarations effectively in the small memory model; in the large memory model reg-

ister variables were useful for integers but not for pointers. The Microsoft compiler makes the best use of register variable declarations; the Wizard and Aztec compilers also are effective. The Computer Innovations and Lattice compilers give good results without register variables, but do not use register variable declarations at all. The Toolworks compiler uses register variables, but produces poor results for these tests.

File I/O is the limiting factor in many applications. The first I/O test measures the speed of the low-level unbuffered I/O library functions (`open`, `read`, `write`, `close`). While these functions are not part of the standard C library (or defined by the current ANSI C document), they are indispensable for many applications. The benchmark copies a 30,000-byte file in 8,096-byte chunks. Results are shown for the file written from floppy disk to floppy disk and from hard disk to hard disk. Because these functions (and their arguments) are not fully standardized, the benchmark source code was tailored to use binary mode in each case. The results are nearly identical for all the compilers, indicating that they all make efficient use of DOS I/O calls.

The standard buffered I/O library functions are appropriate for handling single characters or lines of characters. This benchmark (also contained in listing 7) measures the time needed to copy a 30,000-byte file (twice) using the `getc` and `putc` functions. The default mode (text or ASCII mode) was used for all but the Aztec and DeSmet compilers (which do not offer a choice of modes). Again, times are reported for floppy-to-floppy followed by hard disk-to-hard disk writing. A wide variance was evidenced here in the times returned. `Getc` and `putc` seem to be implemented for convenience rather than for performance in several compiler libraries. The Datalight compiler gave very good results; the Computer Innovations and Aztec compilers also performed better than average.

The use of C for systems programming or general applications may not require much floating-point arithmetic. However, for the application that does use it, speed is likely to be a crucial factor. Results are shown for addition and multiplication (a dot product of two one-dimensional arrays—see listing 7), exponential and logarithmic functions, and sine and tangent trigonometric functions (see listing 8, FLOATPT.C). The first time is for use with software floating-point operations, followed by the time using the 8087 chip (small



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model only.) Several compilers provide more than one floating-point library or compiler option; where possible, a library was used that produced a single .EXE file that worked without an 8087, but used it if present.

The Toolworks compiler produces the best results for software floating-point operations; it performs with only 32-bit precision rather than the 64 plus bits of the other compilers. The Aztec and Mark Williams compilers also are fast with software floating-point; the Computer Innovations and Microsoft products are the fastest with an 8087. The Lattice results for software are slow; with an 8087, its addition and multiplication remain slow, but the exp/log and sin/tan functions perform much faster.

Most of the compilers return a basically similar performance in all of these benchmarks. Times for the small memory model are important in considering the development of small programs or utilities. The times for the large models are more pertinent to developing applications that can make use of more than 64KB of memory for data. If screen output speed is a concern in an application, BIOS calls or writing directly to screen memory should provide an adequate performance.

C CONTENDERS

Eco-C88. Ecosoft, Inc. has been marketing a C compiler for CP/M 8080 systems for some time. The Eco-C88 compiler is the company's first MS-DOS version; its best feature is a library of PC-specific functions. BIOS-based screen output and directory scanning are among the functions provided. The driver program is another strength: it compiles and links a list of files and provides a simple MAKE capability. (It compiles source files for which the object file has an earlier creation date.)

Although the small memory model is limited to a maximum of 64KB for all data, library functions allow the remainder of available memory to be treated as a file. This feature may have limited utility in some applications.

Ecosoft's manual is deficient: the best it has to offer is six pages of practical information on common errors and other programming hints. The function descriptions are quite short and some important topics are not discussed. In addition, neither the start-up code nor the optional library source code is very readable or easy to understand.

Eco-C88's compile and link times and most of its execution benchmarks are about average. This compiler does handle syntax errors much better than

average—no avalanche of spurious messages here. Its floating-point times are average or worse, but the compiled programs are able to sense and use the 8087 chip automatically.

The Eco-C88 compiler is a good buy at \$49.95. It offers reasonable performance and a good set of PC-oriented library functions, but a skimpy manual. It is a bit large for a floppy-disk-based system; a hard-disk system is recommended. However, if the compiler is for personal use and cost is a factor, this product should be considered.

Datalight C Compiler. The Datalight compiler demonstrates how far C compilers have come in two years. In some ways this \$60 compiler is better than any compiler available in 1983. Of course, production-quality C compilers have improved as well, but the Datalight compiler is a useful tool.

Datalight C resembles Lattice C version 1.04 that was tested previously. In fact, the Datalight compiler offers con-

Like other low-priced compilers, the Datalight product does not support the large memory model; for personal use, however, this compiler is a very good value.

siderable compatibility with the Lattice C. It uses the identical assembly language interface and offers some of the same PC-specific library functions. While object files or libraries created with the two compilers cannot be combined, this source-level compatibility does make it easier to use programs prepared for Lattice C.

This compiler's best feature is an excellent implementation of buffered I/O functions. Its `getc/putc` benchmarks are much better than those for the rest of the field. Datalight's buffered I/O functions are good enough to use in applications and utility programs where performance is important.

The library provides gate functions for performing software interrupts and DOS calls, but is weak in PC-specific functions. Full library source code is included. The assembly language source files are well documented, but the C source files have very few comments and are difficult to understand.

The Datalight C compiler and programs compiled with it require DOS 2.0 or later (however, lack of support for DOS 1.1 should not be a serious handicap). Like other low-priced compilers, the Datalight product does not support the large memory model and is not intended for use in developing products. It also shares a common failing of low-priced compilers: marginal documentation. For personal use, however, this compiler is a good value and should be considered a serious alternative.

Toolworks C for MS-DOS. This compiler was inspired by an 8080 small C compiler published in *Dr. Dobbs Journal* several years ago ("A Small Compiler for the 8080s," Ron Cain, May 1980, p.5). The Software Toolworks developed that compiler extensively and has marketed its own CP/M 8080 version for some time. The company has just begun selling a version for the DOS 8088 environment. However, this compiler does not yet reach the level of the other compilers tested.

The basic compiler, at \$49.95, does not support long integers or floating-point arithmetic. A separate product, Mathpak (at \$29.95), modifies the compiler and adds new libraries with the necessary support. Mathpak has a separate manual with separate installation instructions and some modifications to information in the compiler manual.

This creates an unnecessarily inconvenient situation in which the user must refer to two manuals. Further, the manuals are poorly organized and short on library function documentation. However, they explain some topics well, even better than other manuals: command-line arguments, memory layout, and finding out how much memory is available. C functions are grouped by category; they are difficult to identify and find without a list in the table of contents or an index.

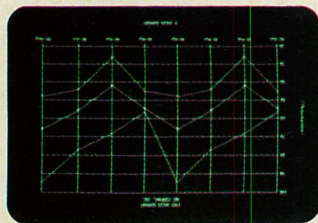
Toolworks' compile times are average—about the same as those for the Eco-C88 compiler, but much slower than those for the DeSmet or Datalight compiler. Its results for the execution benchmarks range from satisfactory to poor, and the programs it produces are significantly larger than those for other low-priced compilers. Finally, while the compiler handles syntax errors poorly, it does give the user a chance to exit after five errors are found.

The Toolworks compiler would have been a sensible product one or two years ago. Now, however, it needs improvement. The basic product should support the full C language and provide better documentation and performance.

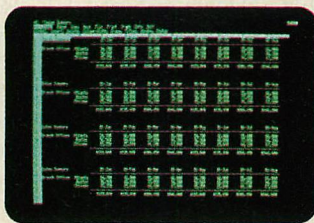
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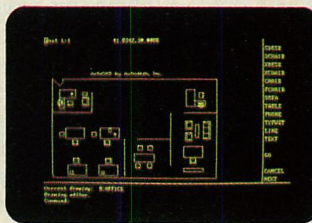
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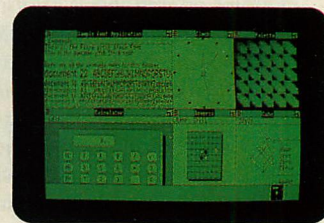
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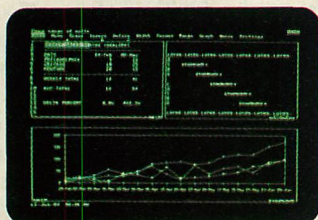
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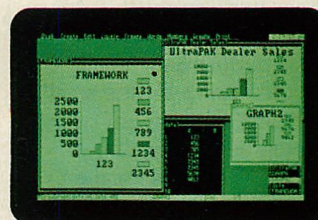
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DeSmet C Development Package. The DeSmet compiler by C Ware Corporation is a standout product now just as it was two years ago. It is very compact, fitting easily on a floppy-disk-based system, and compiles source files very quickly. The compiler produces non-standard object files that are processed by the BIND linker in the DeSmet package. BIND operates faster than the Microsoft linker and requires less disk space. A librarian provides only minimal support for making libraries.

A small, fast assembler is included in the package; it also supports a simplified version of the MASM assembly language. However, the differences are enough to require a substantial amount of editing on Microsoft-compatible assembly language source files.

DeSmet's full-screen editor, SEE, uses modes (command, insert) and has a potentially confusing user interface; but it works without delays and is an improvement over DOS's EDLIN (or the UNIX vi editor.)

The DeSmet compiler does not support the large memory model but it does support overlays, allowing programs with more than 64KB to be produced. Overlays can be placed in RAM to minimize the overhead involved. The optional screen-oriented debugger,

D88, provides more functionality than the Mark Williams debugger, but has a less natural user interface. In addition, D88's documentation requires considerable time and effort. For \$49, though, this debugger is a good value.

The DeSmet package is valuable in the number of quality programs provided. But the value stops short with the manual: function descriptions are too short and some important topics are not discussed properly. This product is a good programming tool for C users with limited funds and the knowledge and patience to work with marginal documentation. C Ware offers several add-on products; like the compiler they are usable and well written, but minimally documented.

The compiler and library have some quirks that make this a less attractive product. The single-pass compiler design does not allow forward references (although pointers to a structure can be declared within that structure). This may force the user to rewrite portions of existing C programs. (A beta test version of DeSmet 2.5 also was examined. It adds UNIX-like support for the void data type, enumerated types, and structure assignment. The documentation also is improved with more information on individual functions.)

Nonetheless, the DeSmet compiler has a real personality. Its speedy compilers make developing C programs fun. Using the compiler is easy—options are few and the default choices are sensible. The basic package includes many extras: assembler, full-screen editor, librarian, RAM disk, and profiler. These extras are genuinely useful, but they will require some effort to be put to use. This product's documentation is sparse, but it is no worse than for other low-priced compilers. DeSmet C is no longer the least expensive C compiler available, but it is still a fine value and well worth its \$109 price.

c-systems C compiler. This product's best feature is its debugger, which displays source code on the screen and lets the user debug without printed source and linker map listings. While it requires more effort than the Mark Williams debugger, it provides greater functionality; for example, directing C library console I/O to a window on the screen. It maintains a separate screen for console I/O so programs using BIOS functions will not overwrite the debugger's screen display. No provision is made for programs that write directly to the PC's screen memory.

The assembler assembles source files faster than MASM, but does not

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support macros or the **struct** statement. With these exceptions, the c-systems assembler does accept the same assembly language.

The manual is a mixed bag. The description of the assembly language interface was better than that in any other product reviewed, and included a brief, but useful description of the statements it accepts. However, compiler usage was poorly documented and the information was split between two chapters. A driver program that provided single-step compiling and linking was not documented at all.

The compiler does not perform well in the benchmarks. Its compile times are much slower and its program sizes significantly larger than for most of the other compilers. Most of c-system's execution results are below average; its performance on long-integer arithmetic is especially poor. The slow execution times are significant, but not a fatal flaw; however, the slow compile times can be a great frustration.

One annoying problem surfaced during the review of this compiler. When the DOS environment string (containing the **PATH=** specification) contained more than 128 characters, several compiler programs behaved erratically. This limitation was not docu-

mented in the manual and the compiler's behavior suggested that this limitation had not been tested properly.

In addition, the compiler generates start-up code only when a function called **main** is compiled. It would be better to have start-up code in a separate source file that could be modified and then maintained properly. Even with its drawbacks, the c-systems compiler, at \$199, is the least expensive product available that supports the large memory model. Library source code is available at \$245 for the DOS 2.0 version and \$45 for DOS 1.1. For the user who requires large memory model support at a low price, this compiler is quite usable and may fit the bill.

Optimizing C86. Like Lattice C, this Computer Innovations compiler was a pioneer DOS compiler. It has improved steadily with features such as large model support and expanded library support for DOS and PC specifics.

Its library functions support interrupts and provide access to PC BIOS services for screen I/O, communications, and parallel printer output. Good documentation is provided for these library functions; the manual also contains 40 pages of short notes on specific topics. A series of application notes in the back cover practical questions, such

as input verification, and advanced topics, such as writing interrupt-driven communications applications in C.

The manual has shortcomings. The topical discussion is somewhat fragmented and the coverage of some topics (such as changing the default stack size) is inadequate. The assembly language interface is discussed but the reader is referred to the distribution disk for examples of complete assembly language source files. (Those source files are poorly commented and are not good examples.) Very little information is provided about linking C programs.

Complete source code is provided for the library functions; its readability varies, but the start-up code (which is read most often) is quite clear.

Because the compiler occupies a lot of disk space, it is not a good choice for a system without a hard disk. CI's compile times are slower than average—about the same as for Microsoft C and slower than for Lattice or Aztec C. Its execution times are quite good for 8087 floating-point operations and file I/O benchmarks; they are adequate for others. Its long-integer arithmetic is the only benchmark in which Optimizing C86 yields poor results.

This product's support of the 8087 coprocessor is a bit limited—a single

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.EXE file uses *either* software floating-point routines or the 8087. The start-up code source mentions a library that switches automatically—perhaps that feature will be supported in future versions. The small and large memory models are supported.

For \$395, this compiler is adequate for production use and offers library source code and the most extensive PC-specific library available.

Microsoft C. Until early 1985, Microsoft was marketing the Lattice C compiler. The company's new compiler, Microsoft 3.0, was developed by Microsoft but is not related to Lattice C. This new compiler is a fine product with good performance and an extensive library.

Two thick, attractively typeset manuals document the compiler's use. The library reference is very effective—well organized with good coverage of individual library functions and topics such as file I/O. The user's guide covers the compiler, the linker, and the librarian program. It is comprehensive, but the detail is overwhelming. Compiler options are covered in an exhaustive 39-page discussion; a quick-reference guide lists compiler options in three pages and is a more useful way to find information on compiler features.

The user's guide also includes a language reference that defines the C language as implemented by the Microsoft compiler. A comprehensive discussion aimed at the experienced C programmer, it is not a concise description of Microsoft's implementation.

This compiler supports several extensions introduced by UNIX C compilers: void return values for functions, the enumerated data type, and structure assignment. It also supports type checking for function arguments as described in the ANSI C draft standard, and the header files provide function prototype templates for library functions.

Microsoft C compiles source files slowly but produces fast-executing programs. It is effective in its use of register variable declarations to improve execution speed. Its floating-point support combines speed with automatic selection of software or the 8087 in a single .EXE file. The approach it uses takes up several thousand bytes, but this is not significant in most applications. (The compiler offers several alternatives for floating-point implementation.)

The Microsoft product requires a large amount of disk space, which would make for quite a bit of disk swapping on a system with two floppy disks. A hard disk is a practical requirement for its use.

As a first version of a new product, this compiler is especially impressive. Its features work, it generates very good code, and its documentation sets new standards for thoroughness. However, for such a complex product with a huge number of options, the documentation should do more to help tame that complexity. Also, its handling of syntax errors is below average.

Most importantly, a C compiler without start-up source code (and library source code to a lesser extent) is not suitable for many projects. These flaws can be fixed easily. As it is, Microsoft C is a very capable product aimed at programmers developing products or sizable in-house applications. It is certainly a leading contender.

Wizard C Compiler. This compiler's best feature is its extensive library, which supplies many MS-DOS and PC-specific functions (such as screen and printer output). The library duplicates many UNIX-specific functions, and is a good choice for programmers also working with C in the UNIX environment.

The Wizard compiler has a comprehensive driver program that compiles and links a list of files (with DOS wild-card characters in the file names). It provides 68 options that require 10 pages of description in the manual. This large number of options can get in the way of the product's better features.

Like the other compilers, Wizard can limit pointer arithmetic to the lower 16 bits (the segment). But one option allows full 32-bit arithmetic to be used when needed. The compiler supports the large memory model.

Assembly language may be embedded in C source files with the `asm` key word. This key word must begin each line to be interpreted as an assembly language statement—a less convenient mechanism than the `#asm` and `#endasm` preprocessor statements used by other compilers. In-line assembly language use is better documented in the Wizard manual than in any other. The manual also offers good documentation of individual topics related to interfacing to separate assembly language source files, but it would be much more useful with an example.

Overall the manual is only average; its discussions are abstract rather than practical, even though many contain good information. It is not well organized and its index does not contain enough functional entries, compromising its usefulness. Nevertheless, its language reference section covers the entire language rather than just the Wizard implementation differences.

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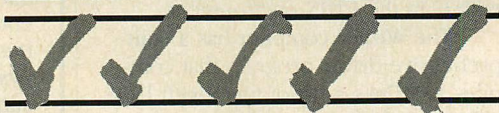
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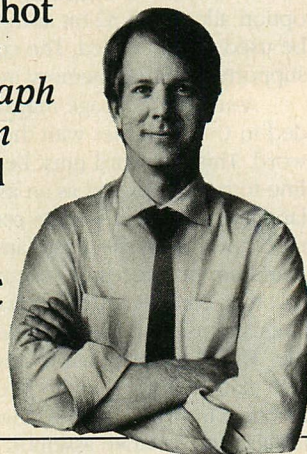
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Full library source code is provided. As with several other compilers, the assembly language source code is well commented and readable, but the C source code is poorly commented.

The compiler's performance makes it very useful in serious software development. Its compile times are faster than average and most of the execution benchmark results are good. Its floating-point operations using the 8087 chip are a bit slow and it is slower than average in long arithmetic.

Wizard C is a reasonable choice for serious development work. Its strengths are an extensive library (that includes source code), the LINT option, and its quick compile times.

Lattice iAPX86 C Compiler. Lattice C was one of the first C compilers available for the MS-DOS environment. It is published and supported by two sources: Lattice, Inc. and Lifeboat Associates. The version tested, 3.0, is a major revision that adds many library functions and some important extensions, and delivers a smaller .EXE file size.

A key advantage to this compiler is its large base of users. Because of it, Lattice C has the best range of specialized libraries available, both from Lattice, Inc. and from third parties. In addition, the large user base gives Lattice incentive for providing regular updates, fixing bugs, and introducing improvements. (Lattice, Inc. now offers minor updates free and notifies registered users when they are available.)

Lattice C supports several UNIX C extensions: functions returning void data types, enumerated data types, and structure assignments. It also supports the function argument checking feature in the proposed ANSI C standard. Its library supports DOS 3.1 file sharing and record locking and duplicates a number of UNIX C library functions. It also provides a number of functions for specific DOS services. A noticeable omission is functions for screen output (cursor movement and attribute control).

This Lattice compiler offers the user a good combination in that it includes many features but remains simple to use. A driver program compiles a list of files and accepts DOS wild-card characters without adding complication. In addition, the distribution disks provide batch files for compiling and linking with different memory models.

The 3.0 update manual documents the entire function library; its alphabetical organization with single-line function descriptions in the table of contents is an improvement over previous Lattice manuals. The manual itself has

been revised and is one of the most usable in the group.

Lattice C provides a **getml** library function that allocates objects larger than 64KB; with a compiler option to perform 32-bit arithmetic on pointers and addresses, Lattice provides a convenient way to use arrays larger than 64KB. This example shows how an array of 30,000 floating-point numbers can be created and addressed:

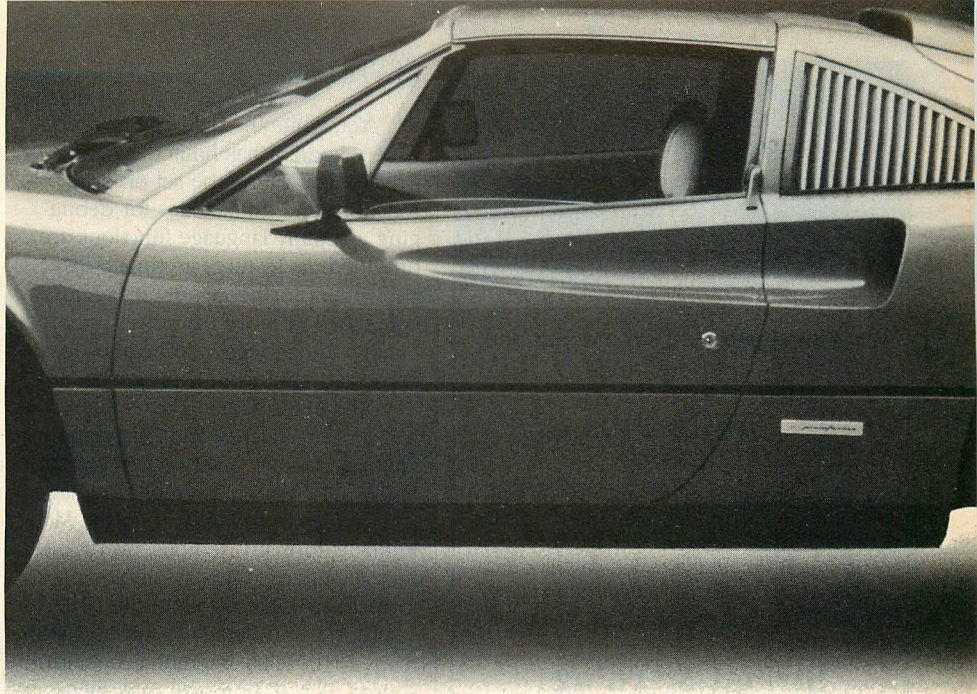
```
float *big array ;
char *getml( ) ;
big_array = (float *) getml(30000 * (long)
    sizeof(float)) ;
sum = 0.0 ;
for(i=0 ; i<30000 ; i++)
    { sum = sum + big_array[i] ; }
```

Lattice C compiles source files quickly; its link times (using the DOS LINK program) are average. The compiler's performance in the execution benchmarks is generally good with some exceptions: it does not use register variable declarations, its file I/O with **getc** and **putc** is slow, and its speed is below average in floating-point operations. (A compiler option for in-line 8087 support produced a very competitive time for the floating-point add/multiply benchmark, but the product's library support for this option was incomplete.)

Perhaps the worst aspect of Lattice C is its "a la carte" pricing: \$500 for the compiler (and a librarian), \$500 for library source code, \$195 for a MAKE equivalent program, and \$175 for a source-level debugger. (This debugger is not screen oriented and does not give access to local variables by name.)

Lattice C is a mature product with good features and a lot of support in specialized libraries. It is priced like a Mercedes and for the most part it is worth it. A few performance weaknesses should be corrected, but it is certainly a fine product to consider for the production of important applications.

C Programming System. The star of this package is its source-level debugger, which has an excellent user interface. The manual provides a tutorial on the basic concepts and a plastic template is included, eliminating the need to memorize debugger commands. Single PC function keys are used for the commands and C source code around the current program counter location is automatically displayed. Separate copies of the screen are kept for source code display and for program output so that screen output need not interfere with normal debugger display. Using this debugger is very much like using a good screen-oriented text editor.



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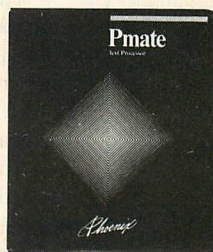
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Yet, while the debugger's interface is very good, it has limited capabilities. Breakpoints cannot be set on library functions and no facilities for debugging assembly language functions are provided. Its features are much less convenient for debugging programs composed of more than one source file. Finally, the debugger sometimes loses console output from C programs.

The Mark Williams assembler does not support macros, and its assembly language format is very different from MASM's. Rewriting assembly language source files from MASM to fit the Mark Williams format is tedious; every line must be altered. This assembler's format is similar to that of the UNIX assembler, an advantage to the user with many UNIX 8086 assembly language source files. If, however, most of a user's source files are in the MASM format, the Mark Williams assembler may be more trouble than it is worth.

The compiler can invoke the Mark Williams linker as part of a single compile and link command; the linker is rather complicated to use directly. Because the linker supports only the small memory model and is slower than DOS LINK, it adds little value to the product.

The library contains the standard C functions and general PC-specific functions (port I/O, memory access, software interrupt gate function). Few functions for specific DOS, BIOS, or PC hardware services are included.

The manual covers the compiler itself, the Mark Williams assembler and linker, and the source level debugger. It is poorly organized and fails to cover important topics such as memory layout, setting the stack size, and console and device I/O. Neither the table of contents nor the index is much help in locating answers to practical questions. Usage of the MASM assembler and the DOS linker with the Mark Williams compiler is also poorly documented.

Its compile times are good for a production compiler. Link times with its own linker are slower than for other compilers. Its execution results for the sieve benchmark are good, but its other times (those for function calling and integer and long-integer arithmetic, for example) are worse than average.

The various parts of the Mark Williams package are not well integrated. The source level debugger works only with .EXE files created with the Mark Williams linker. But 8087 support and the large memory model require that files be linked with the DOS linker. The manual's information on the use of MASM and the DOS linker is limited.

The Mark Williams package (\$495) is a potentially attractive product, but more attention should be given to detail.

Aztec C86. Manx Systems sells its C compiler in several forms. The Commercial System (\$499) includes a compiler that supports several memory models, library source code, an assembler and linker, and a number of utility tools (an editor, MAKE program, and ROM support, for example). The Developer's System (\$299) does not include library source code or the utility programs. A Personal System (\$199) includes an older compiler that supports the small model only and produces slower executing code. The Apprentice System (\$49) is a C interpreter limited to programs composed of a single source file. This review applies to the Commercial and Developer's Systems.

The benchmark performance is quite competitive with other production compilers. Its compile times are good—only the Wizard compiler produces significantly faster times—and its execution times are very good—close to the best on most tests. The subscript (char count) benchmark could not be run with the large memory model; the Aztec compiler hung when compiling that part of the program. This is a serious flaw—compiler crashes should never happen—but no problems surfaced with other C source files.

The Aztec product's library provides support for text mode translation for console I/O only. This allows library file I/O functions to be smaller and faster in some cases; however, it also means that certain existing C programs may need to be rewritten.

The linker provides functions equivalent to those of the DOS LINK. It supports overlays, but only for the small memory model, which limits their value. The construction of overlays is well documented. Its link times are faster than average. This linker is a competent alternative to the DOS linker, but it offers little extra value. The assembler supports most of the MASM assembly language format and statements; the STRUCT statement, however, is omitted.

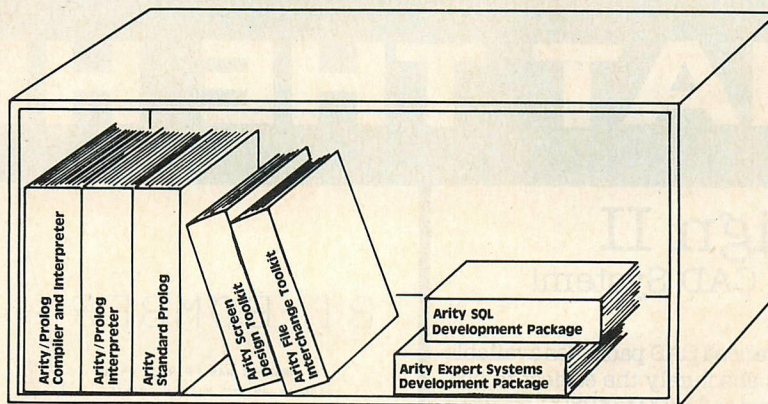
Aztec C can generate standard OBJ files for use with MASM and DOS LINK. Little documentation is provided on using Aztec C with these programs.

The manual contains good information, but is poorly organized. The modular arrangement, with separately numbered sections, is convenient for the compiler vendor but an annoyance for the compiler user. The addition of a good index might help. The manual covers CP/M 8080, Macintosh, and Apple

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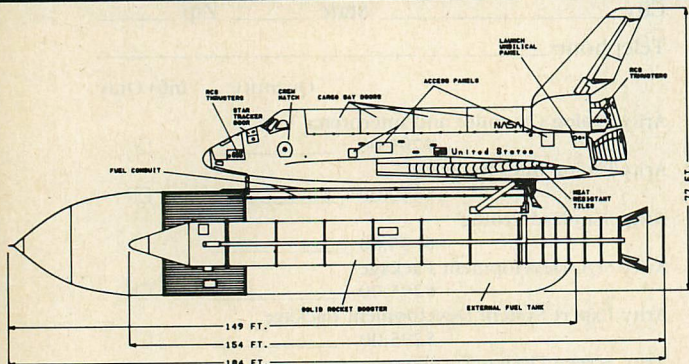
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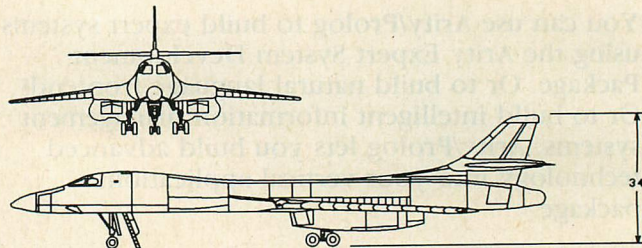
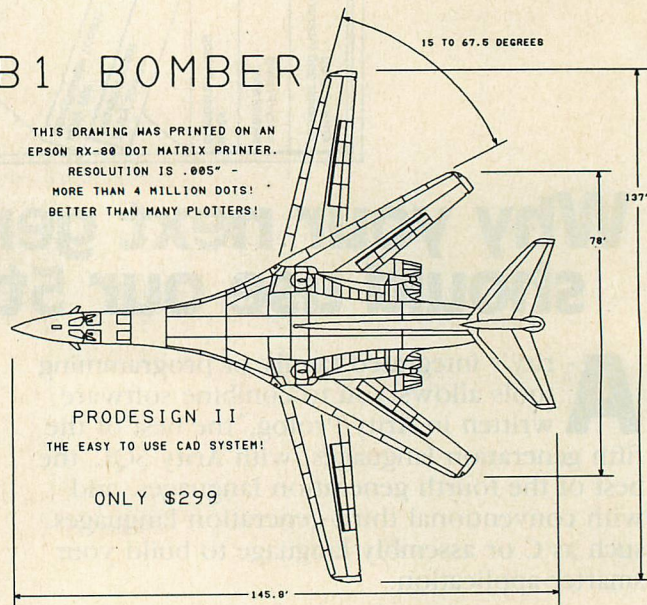
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II versions in addition to the DOS version. The topical discussions are difficult to use because perhaps 75 percent of the material pertains to other environments. The function descriptions have sufficient detail, but are organized by category with an alphabetical index at the start of each section. The assembly language interface description covers individual issues well and provides short examples.

A screen editor, Z, included in the Aztec product, provides the equivalent of the UNIX vi editor. It may be familiar to some programmers, however, many DOS editors are superior.

At \$299, the Developer's System is a better buy than the full \$500 Commercial System. (Users can upgrade later.) It offers good compile and execution times and a good PC-specific library at a low price. The manual is adequate, but not easy to use. Aztec C is a good value and should be considered for serious software development.

Digital Research C. This version of the DRI C compiler seems to be very much the same as the version reviewed previously. It has a few good features, but it is mostly out of date and in need of major improvements.

The results for the floating-point (dot product) benchmark are quite competitive and those for the subscript and subscript benchmarks in the same memory model also are good. The manual makes an effective use of color and boxing to highlight figures and tables. The linker supports overlays but its lack of support for file path names makes the overlay feature virtually useless.

The library has no gate functions to give access to DOS or BIOS services. No library functions are included to perform specific DOS or BIOS calls or to access the PC hardware. A single function, IBMDOS, performs DOS calls but permits the user to specify the contents of only two registers. (The manual does not specify which two.) The benchmark results for arithmetic on long integers is about nine times as long as the best compiler's time. The programs produced by this compiler are considerably larger than most others. The manual provides no guidance for linking C programs. For example, no explanation is offered for setting the stack size for C programs.

The manual contains no references to DOS 2.0, subdirectories, or path names for files. Its discussion of the assembly language interface contains useful information but serious errors as well: function arguments are declared as external variables in the calling function

and as public symbols in the assembly language function being called.

The compiler produces .OBJ files compatible only with the linker and assembler in the package. This assembler recognizes the same instruction formats as MASM, but does not support macros. The documentation fails to explain the use of the assembler and linker in the context of a C program.

The compiler, linker, and assembler seem ill-matched. The compiler (and the linker) distinguish between uppercase and lowercase in public symbols. The assembler default converts public symbols to uppercase. The manual suggests that using lowercase names for functions implemented in assembly language is an error. (One assembler option preserves lowercase public names; the manual should suggest its use instead.) Many of the differences among products in this review are minor; the faults of this compiler are major. Its price is \$350.

CURRENT C

The state of C on the PC is excellent. More programmers use C than ever before and more good C compilers are available. Some important product trends are noteworthy:

- For \$50 to \$110, a programmer can buy a C compiler that is as good as or better than the best product available two years ago. While these products do not offer the features of expensive compilers, they are useful tools for personal use.
- Compilers intended for serious product development support a variety of memory models with different trade-offs between execution speed and ability to use large amounts of RAM. They also offer more features and somewhat better performance than low-priced compilers.
- Most compilers now make good use of DOS features. They perform disk I/O efficiently and recognize full path names for files to support hard disk subdirectories.
- Most libraries now include generic gate functions to access DOS, BIOS, and PC hardware services. Some compiler libraries also provide a number of functions for specific DOS services, such as getting the current date and time or scanning a directory.
- Several compilers offer an environment that closely matches the UNIX environment. Others concentrate on making all the capabilities of the PC hardware environment available.
- Several products include debuggers that allow the user to control execu-

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tion in terms of C statements and to display and modify values of C variables. Source debuggers are offered as separate products at extra cost by other vendors.

Like other software products, C compilers must be supported and enhanced to maintain their usefulness. No vendor can do this without a customer base and continuing sales. It seems unlikely that the market for C compilers can support 12 vendors. Variations in performance and features among competitive compilers are not substantial. For the average C user, his knowledge of C, the 8088 architecture, and using DOS services will determine the individual quality of the results he achieves.

In the past, C programmers had to manage with poor documentation and ferret out crucial implementation details on their own. Now many C users are applications-oriented programmers who need good, helpful documentation. The successful vendor will invest time and effort to make its products as useful as possible for the C programmer.

Because the C compiler market is crowded, vendors must update their products frequently to remain competitive. As compilers are updated, the detailed descriptions in reviews such as this become obsolete. But part of the purpose of a product review is to spotlight inadequacies as encouragement to vendors to make improvements.

One conclusion seems clear from an evaluation of these compilers: good documentation does not come cheap. Further, it is often the last item a compiler vendor provides; not every expensive compiler provided good documentation, but all the inexpensive compilers came with skimpy material.

It is easier to point out products that need improvement than to rank the clear winners. The Software Toolworks C, for example, is simply out of place with the other low-priced products. With full C compilers available for \$50 and \$60, a subset compiler that produces large, slow-executing programs seems of little use. The \$350 DRI compiler is not a good buy because of its poor performance, an inadequate library, and poor documentation.

For the user selecting a compiler for personal use with price as an important consideration, the C Ware DeSmet, Datalight, and the Ecosoft Eco-C88 compilers are all reasonable alternatives. Eco-C88 offers a good driver program and PC-specific library. The Datalight compiler's excellent implementation of buffered I/O makes it very useful for writing utility programs. The

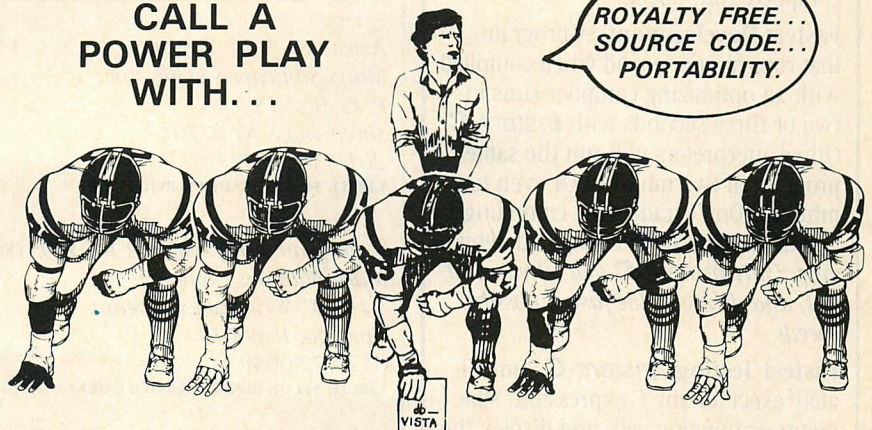
DeSmet compiler is more expensive, but it is worth the difference: its compile and link speeds are very attractive, and its assembler and screen editor provide a complete set of tools for program development. It is the best choice by far for a system limited to two floppy disk drives (and no RAM disk).

If a source-level debugger is an important consideration, the user must accept compromise. The C Ware and Mark Williams debuggers work only with the small memory model. The c-systems debugger supports the large

memory model, but the accompanying compiler delivers below-average performance in compile time, program size, and execution speed. Separate source-level debuggers are available for Lattice C and Computer Innovations.

For a production-quality compiler, Computer Innovations, Lattice, Wizard, Manx Aztec, and Microsoft are reasonable choices. The Mark Williams debugger makes it an attractive product, but the balance of the package—the compiler's features, documentation, and limited library—are substandard.

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STATE OF C

The Computer Innovations compiler has the best PC-specific library available; other compilers also provide a number of these functions. The CI library provides access to almost all the PC's capabilities; library source code and a librarian are its other advantages. Lattice C is supported by a more specialized group of add-on libraries than any of the other compilers. Its documentation and simple operation make it more usable than some of its competitors, and its compile times are above average. Its program execution benchmarks are mostly satisfactory.

Wizard C offers fast compile times, and good execution times for most of the benchmarks. Library source code is included, but a librarian program must

be purchased separately. The Manx Aztec compiler offers fine performance, a librarian, and an assembler for \$299. The \$500 version has a number of utility programs, library source code, and free updates for a year.

The Microsoft compiler comes closest to being the clear winner. Its compile times are noticeably slower than most of the competition and its start-up source code is lacking, but the Microsoft performance in the benchmarks for program execution is the best of the lot overall. 

William J. Hunt is the author of The C Toolbox, a book about software tools and C programs that illustrate real-world functions. It was published recently by Addison-Wesley.

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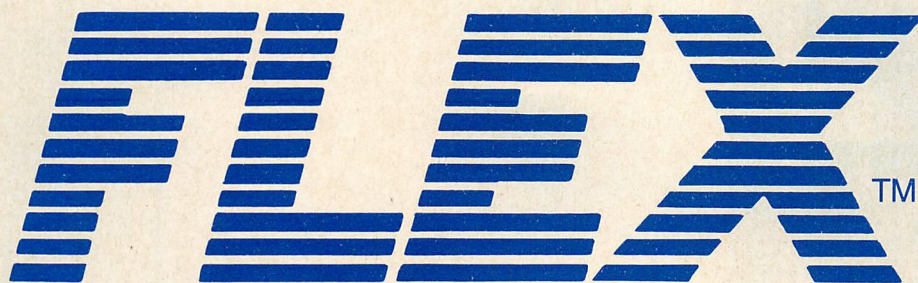
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SPECIFICATIONS

Environment:
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Requirements:
52K TPA (8-bit)
256K TPA (16-bit)
CRT w/cursor addressing
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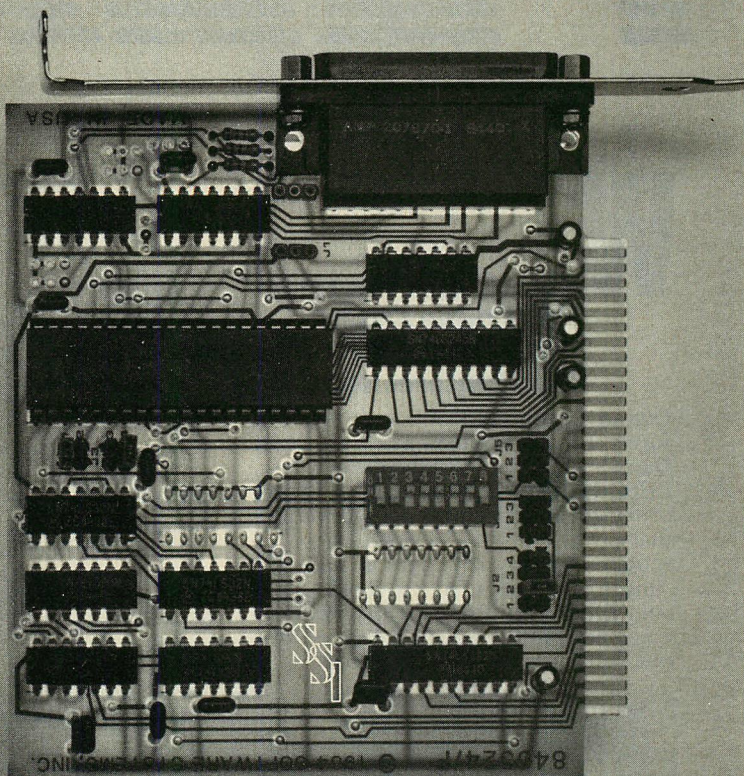
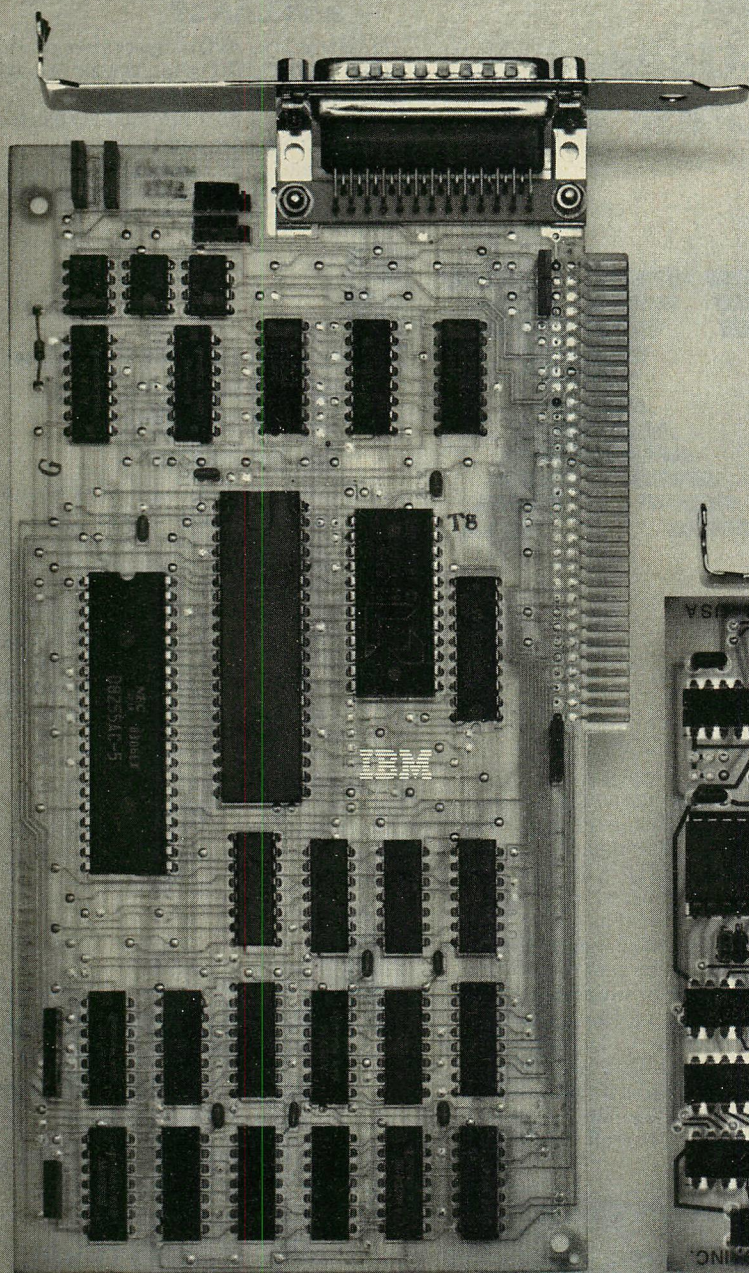
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```

500 A.FUNC% = 3
510 A.STR$ = "000T0T0TJimSmith"
520 A.LEN% = 17
530 CALL BLIM(A.FUNC%,A.STR$,A.LEN%,A.RC%)

```

Keystroke Automation

The IBM High Level Language API allows a 3270-PC program to do anything the 3278/79 terminal operator can do, including "pressing" keys.

New tools for establishing micro-computer-to-mainframe links appear almost daily. Some require cooperating programs on both ends of the link; others work solely from the microcomputer. Many, if not most, of these tools take advantage of the ubiquitous IBM 3278/79 terminal specification (the 3279 is basically a 3278 with a color display), beginning from a framework of emulation.

Unlike common asynchronous terminals, which transfer information one character at a time, the 3278 transfers data in blocks through a synchronous line. Typically, a block consists of the characters that comprise one screen of data, plus screen formatting information. When the terminal user types at the keyboard, the characters are stored in a buffer. They are formatted into a block and sent out on the synchronous

line when the user presses Enter. Similarly, the remote mainframe sends data to the 3278 terminal in blocks with embedded screen control codes.

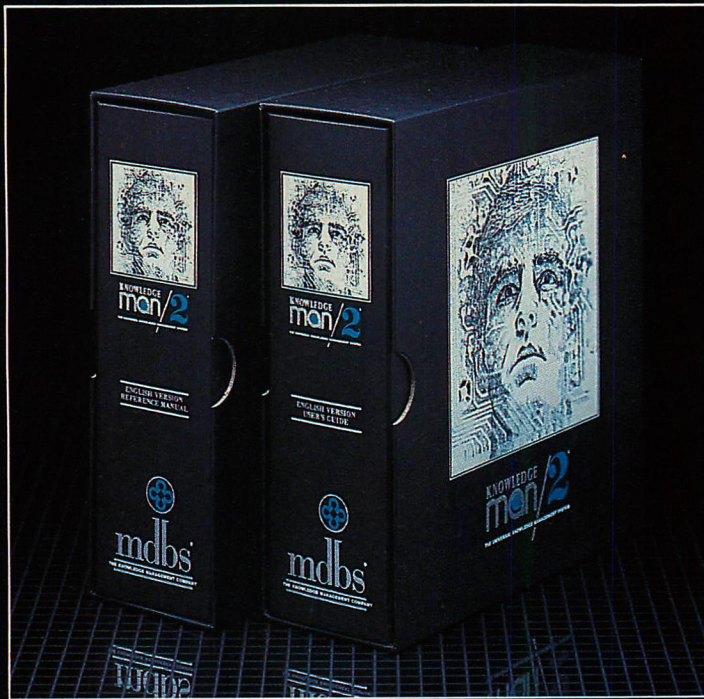
All 3278 hardware emulation products provide PC software that handles the display of the 3278 terminal screen and allows the user to key data into that format. Some include an application program interface (API), which acts as a poor man's micro-to-mainframe data

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transfer product. With the help of the API, a PC program can act as the terminal operator: moving data to or from the 3278 terminal screen, moving the cursor around, and pressing the Enter or PF (program function) keys—an automated terminal operator.

In the IBM world, the 3270-PC and 3270-PC High Level Language API provide the user with the capability to write simple programs that move data back and forth between the PC and existing mainframe application programs.

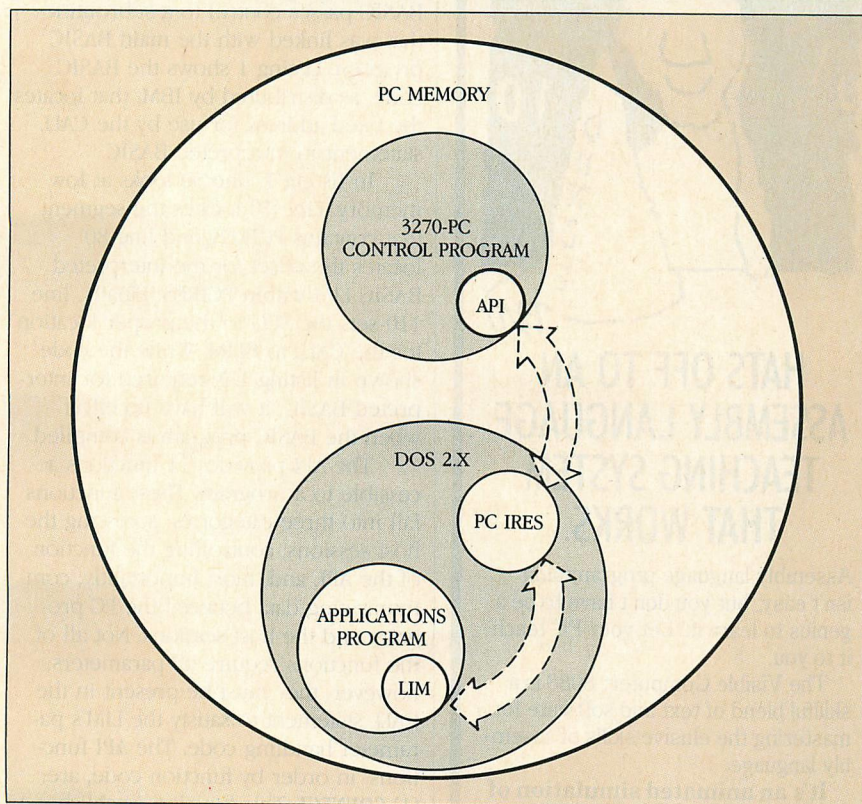
The 3270-PC, a special version of the PC and PC/XT, has terminal emulation capabilities built in. In fact, the 3270-PC can window four 3278 type terminals, two notepad areas, and a DOS terminal at the same time. In 3270-PC jargon, the area inside a window is called a *presentation space*. The 3270-PC is well suited for terminal emulation, with its excellent high-resolution color monitor and a keyboard that includes both PC and 3278 terminal keys.

Creating a micro-to-mainframe data transfer system is easy once all of the pieces are in place. All that is necessary are a 3270-PC with the 3270-PC Control Program 1.2, the High-Level Language Application Program Interface (API), the BASIC interpreter, and an applications program such as WordPerfect or Displaywrite 3 that can import and use BASIC sequential files.

Figure 1 illustrates the operating environment of the 3270-PC with all of the software pieces in place. Completion of this picture requires the operator to go through several steps. When the 3270-PC is turned on, the familiar memory test and DOS boot will take place. At the DOS prompt, the command that activates the 3270-PC Control Program is entered. The 3270-PC Control Program, which is separate from DOS, will reboot DOS. (The Ctrl-Alt-Del combination for clearing out PC problems has a different meaning in this situation. DOS can be rebooted without affecting the 3270-PC Control Program. If the control program is the cause of any problems, however, the power switch is the only way out.)

The API (the code that actually carries out the functions requested by the application program) is contained within the control program. Getting a request to the API requires a few more steps. Entering PCIRES at the DOS prompt loads the resident portion of the API language interface. (PCIRES loads itself as a resident extension of DOS.) PCIRES communicates between the language interface module (LIM), which has been linked into the applica-

FIGURE 1: 3270-PC Software Environment



After the 3270-PC Control Program has rebooted DOS, entering PCIRES at the DOS prompt loads the resident portion of the API language interface. PCIRES communicates between the language interface module (LIM), which has been linked into the application program, and the API in the 3270-PC Control Program.

tion program, and the API contained within the 3270-PC Control Program.

Finally, the application program itself begins to run. Several languages are supported, including BASIC (interpreted and compiled), IBM COBOL, IBM Pascal, and the Macro Assembler (MASM). The support is provided by the LIM, which is linked with the program. IBM provides LIM object modules for the languages listed above. For other vendors' compilers, it will be necessary to write an LIM using MASM and the linkage conventions for the particular language compiler. Fortunately, IBM provides source code for PCIRES and the different LIMs included in the package.

The function of the LIM is quite simple. It reformats the data from the four variables in the call statement into a *parameter control block*. The LIM then invokes PCIRES using a software interrupt. From BASIC, the following CALL statement would be used:

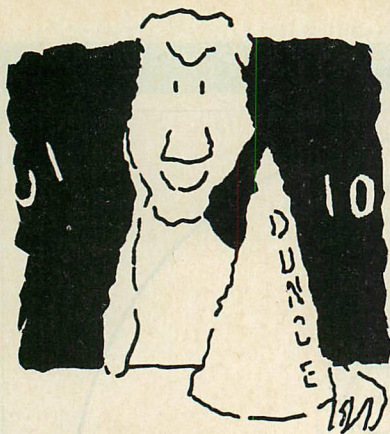
```
1000 CALL
      BLIM(A.FUNC%,A.STR$,A.LEN%,A.ARC%)
```

The first variable A.FUNC% is given a value from 1 to 12, depending on the desired API function. A.STR\$ will con-

tain data to be sent to a host session or to be retrieved from one. The user must indicate the length of the data to be sent or retrieved by setting A.LEN% to an appropriate value. Finally, when control is returned to the application program, the A.ARC% return code variable will contain a value that indicates the success of the requested function. (For some API functions, A.ARC% is used to pass information to the API.)

If a program were in compiled BASIC, it would first have to be linked with the BASIC LIM. Interpreted BASIC is handled quite differently. The LIM for interpreted BASIC is contained within the PCIRES module itself, and is located using interrupt 45. The vector for interrupt 45 is established by PCIRES when it makes itself resident in memory.

The interpreted BASIC LIM resides within the PCIRES module for several reasons. First, external subroutines cannot be linked into the BASIC interpreter. The authors could have used BLOAD or POKE to install the LIM; however, it would be nice for the code to be compatible between interpreted and compiled BASIC. For this reason, a CALL statement is used that in inter-



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API

interpreted BASIC passes control to a fixed memory address and in compiled BASIC passes control to a subroutine that was linked with the main BASIC program. Listing 1 shows the BASIC code, as distributed by IBM, that locates the fixed address for use by the CALL statement in interpreted BASIC.

In listing 1, line 50 looks at low memory. Line 70 locates the segment that contains PCIRES, and line 80 locates the offset for the interpreted BASIC LIM within PCIRES. Finally, line 110 sets the SEG to the proper location for the CALL to BLIM. While the code shown in listing 1 is required for interpreted BASIC, it will have no effect when the BASIC program is compiled.

The API provides 11 functions accessible to a program. These functions fall into three categories: accessing the host sessions, controlling the function of the API, and, most importantly, communicating data between the PC program and the host sessions. Not all of the functions require all parameters; however, they must be present in the CALL statement to satisfy the LIM's parameter-handling code. The API functions, in order by function code, are:

(1) CONNECT. This function establishes a logical connection between the PC program and the specified host or notepad session. This connection must be established before sending or receiving keystrokes from a session. Two types are possible: a *logical* connection keeps the DOS session in the active presentation space; a *physical* connection causes the 3270-PC Control Program to jump to the requested session, making it the active presentation space. It is also possible to CONNECT to workstation control mode, where the program can access control program functions such as sizing and moving windows.

(2) DISCONNECT. This drops the connection between the PC program and the last connected host session. It is not necessary to DISCONNECT between each call, but the manual advises a DISCONNECT at the end of the program. Failure to do so, the manual states, "can inhibit the use of other 3270-PC functions." A cryptic warning, at best.

(3) SEND KEY. In essence, this function emulates a person typing at the keyboard. It sends a series of keystrokes from the application program to the connected host session. The keystrokes are placed on the screen at the current cursor position. It is the user's responsibility to ensure that the cursor is in the proper location before sending data to the connected host session. This can be accomplished by sending the appro-

priate combination of home field, Tab, and arrow keys.

Some keys on a 3278 terminal have no ASCII equivalents—the Clear key and the PF (program function) keys, for example. These keys can be included in the data stream using an escape character followed by a special code character such as E for the Enter key or T for tab. The default escape character is @. If A.STR\$ is set equal to @E and the SEND KEY function is invoked, the API will press the Enter key on the connected host session.

Host 3270 formats are displayed on the terminal using structured fields. Each structured field defines its location

In essence, *SEND KEY* emulates a person typing at the keyboard. It sends a series of keystrokes from the application program to the connected host session.

on the screen, its length, and its video attributes. The video attribute defines the field's intensity (or color) and whether the field is protected (display only) or unprotected. Data can be keyed only into unprotected fields. One structured field in the format will be defined as the *home field*. When the format is first displayed, or when the home field key is pressed, the cursor will appear at the start of this field. (The home field is not necessarily the first unprotected field on the screen.)

SEND KEY is used this way:

```
500 A.FUNC% = 3
510 A.STR$ = "@0@T@T@TJim Smith"
520 A.LEN% = 17
530 CALL
```

```
BLIM(A.FUNC%,A.STR$,A.LEN%,A.RC%)
```

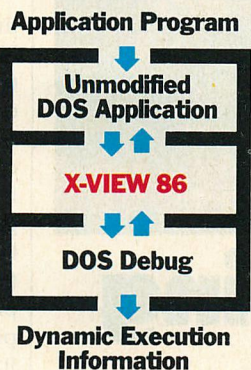
Assume that a BASIC program will fill in the name field on a format that has been displayed on a host session. The name field happens to be the third unprotected field on the format. The first unprotected field is the home field.

Line 500 sets the API function code to 3, indicating that keystrokes are to be sent to the 3270 session. Line 510 defines a string of data that the API will type onto the connected host session. These data include three tab characters defined as escape sequences with @ as

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the escape character. Line 520 defines the length of the data string A.STR\$. Line 530 calls the LIM, passing along the four variables that define this call.

The @0 in line 510 of the above example is the ASCII representation of the home field key; in effect, it "presses" that key. (The @0 characters do not appear on the screen.) The @T sequence has the effect of pressing the Tab key three times, which ensures that the cursor is now on the third field of the format. Finally, the literal Jim Smith is typed on the screen.

One warning about entering data into unprotected fields: some unprotected fields are defined as *autoskip*—when a character is typed into the last position of the field, the cursor will skip automatically to the beginning of the next field. Any one of several conditions can occur: the characters will not entirely fill up the name field; the characters will fill up the name field exactly, which will move the cursor to the next field; or the characters will overflow the name field and spill into the next field on the format. When autoskip fields are

present, the program must be prepared to handle any of these situations.

SEND KEY places keystrokes on the terminal at about the same speed as someone typing. The manual states, "The interface is designed to simulate interactive terminal activity." However, users should note that file transfer applications are discouraged.

(4) **WAIT.** This function checks the status of the connected 3270 host session. The 25th line of a 3270 display contains terminal status information. An X next to a clock symbol or next to the word SYSTEM indicates that the terminal is in the process of sending data to or receiving data from the host session. The program cannot access the API functions until this condition has cleared.

WAIT will set the return code ARC% depending on whether or not the session is waiting on a host response. Three different modes can be specified for WAIT: test the status and return immediately, pause a few seconds and return, or wait forever (if need be) for a host response. Obviously, the wait forever option should be used with great care.

Typically, on a mainframe system, the operator presses the Enter key or a PF key and waits for a response from the host. A user's BASIC program must do the same thing by issuing a WAIT to see if the host response has been received. If the response time of a mainframe system is slow, the BASIC program may issue several WAIT calls before the host response is received. (5) **COPYPS.** With this function, the entire presentation space is copied into the program, and characters are translated into ASCII. Approximately 3,270 attribute bytes (characters not displayed on the host session that define the video attributes of the displayable data) are converted into blanks.

```
500 A.FUNC% = 5
```

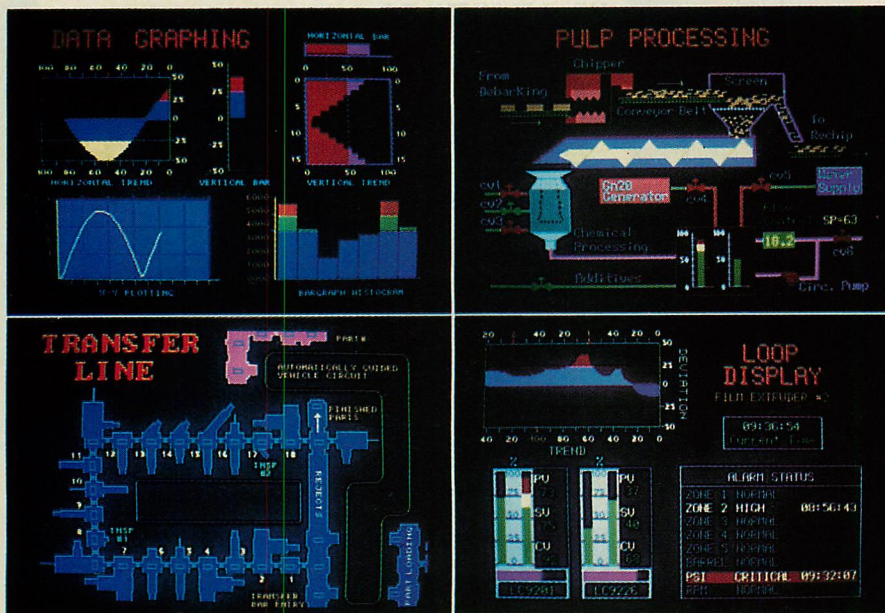
```
510 A.STR$ = space$(1920)
```

```
520 CALL
```

```
BLIM(A.FUNC%,A.STR$,A.LEN%,A.ARC%)
```

Line 510 preallocates a string that can hold 80 columns by 24 rows or 1,920 characters of data, the standard size of a 3278 model 2. Because the 3270-PC emulates a variety of terminal types, the QUERY SESSIONS function (below) should be used to determine the size of the current host terminal. This function cannot be used in interpreted BASIC due to the length of A.STR\$.

(6) **SEARCH.** This function searches the entire active presentation space for a specified string. If the string is located, its starting offset is returned.



No Programming Required.

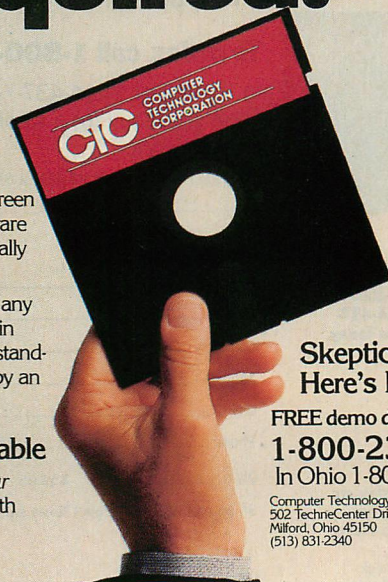
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In the following example, the last connected host session is searched for the character string Jim Smith. If the string is found, its location will be returned in ARC%. The string location is expressed as a one-dimensional offset into the host presentation space rather than as cursor coordinates: 1 to 1,920 for a 3278 model 2. A return code of 0 indicates that the string was not located.

```
500 A.FUNC% = 6
510 A.STR$ = "Jim Smith"
520 A.LEN% = 9
530 CALL
    BLIM(A.FUNC%,A.STR$,A.LEN%,A.RC%)
```

(7) **RETURN CURSOR POSITION (Undocumented).** This product seems to offer no function that would return the cursor location on a host session (which is very useful information). However, a closer examination reveals that this capability is contained within the PCIRES module, even though the manual gives no indication of its presence. (The PCIRES source code must be consulted.) Function code 7 will cause the API to place the cursor location in ARC%. Remember that using undocumented features can be tricky.

(8) **COPY STRING.** With this function, the program copies a string of data from a host session into itself—the opposite of SEND KEY. However, while SEND KEY uses the current cursor position to start typing data onto the host format, COPY STRING needs to know the offset of the data on the host session.

In this example, the user wants to extract 20 bytes of data from a host format, starting at offset 81, which is the first column of the second row.

```
500 A.FUNC% = 8
510 A.STR$ = SPACE$(20)
520 A.LEN% = 20
530 A.RC% = 81
540 CALL
    BLIM(A.FUNC%,A.STR$,A.LEN%,A.RC%)
```

Line 510 preallocates a string to hold 20 bytes. Line 520 indicates the length of A.STR\$, and line 530 indicates the offset of the data on the host format. Note the use of ARC% to pass information to the API. When control returns to the BASIC program, the variable A.STR\$ will contain whatever data are shown on the screen at the given offset.

(9) **SET SESSION PARMS.** A variety of parameters can be set that affect how the API handles the other function calls.

(10) **QUERY SESSIONS.** This returns a description of all host and notepad sessions currently defined to the 3270-PC control program. Its use is shown in the following example.

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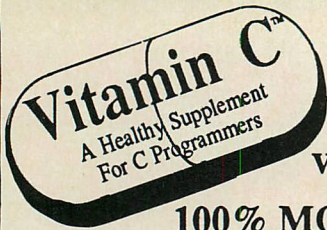
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API

500 A.FUNC% = 10

510 A.STR\$ = SPACE\$(72)

520 A.LEN% = 72

530 CALL

BLIM(A.FUNC%,A.STR\$,A.LEN%,A.RC%)

The API will place a session descriptor for each defined host or notepad session into A.STR\$. Each session descriptor is 12 bytes long, a maximum of six (four host and two notepad) sessions can be defined, so at least 72 bytes of space are needed. The format of the session descriptor is the session short name (1 byte, ASCII character), the session long name (8 bytes, ASCII characters), the session type (1 byte, ASCII character; H = host, N = notepad), and session size (2-byte, binary number).

These four items are defined at 3270-PC control program generation time. The session size is the number of columns times the number of rows for the type of terminal being emulated. The session short name must be known for the CONNECT function, and the session size for the COPYPS function.

(11) RESERVE. Reserve inhibits keyboard input to the currently active session.

This is necessary due to the multi-tasking capability of the 3270-PC control program. Suppose the BASIC program is running, sending transactions to the host. Unless that host session is RESERVED, the terminal operator can jump to and try to use the same session that the BASIC program is using.

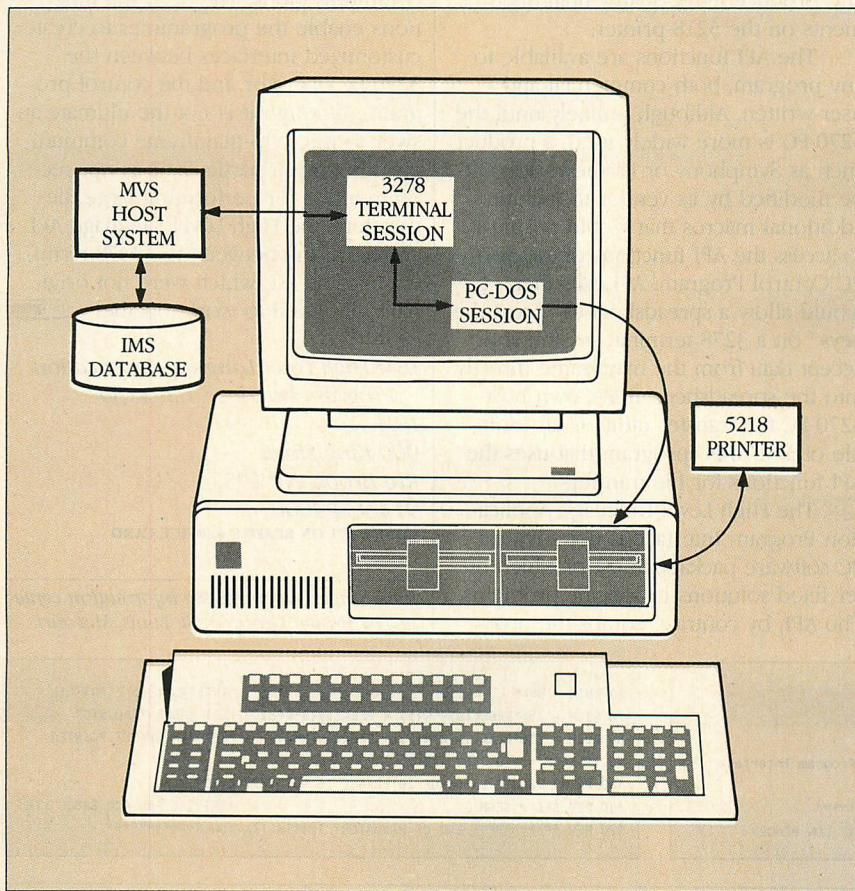
(12) RELEASE. This function releases a session that was previously RESERVED.

Building a "robot operator" using these API functions is similar to programming a Lotus macro. In macro definition, the user first goes through a process step by step and determines exactly what keystrokes are necessary, then those keystrokes are entered into a spreadsheet cell. To make the macro more powerful, conditional and iterative forms of logic can be added.

To build an automated operator, the user must determine carefully the steps necessary to perform the main-frame function that is to be automated. Each time data are entered into the terminal, he must note which fields are used and their lengths. Each time the system responds with a screen full of information, he must note the row and column location of the important data. With this information, the user can program in the language of his choice.

Figure 2 shows a 3270-PC application that uses the API functions. (This application illustrates a specific example; it is not the only way in which the 3270-PC API may operate.) At the left of

FIGURE 2: Sample 3270-PC API Application



The IBM MVS host system at left is running IMS DB/DC (information management system database/data communication). IMS is a transactional database system that runs on IBM mainframes. The display screen of the 3270-PC shows two windows: an emulated 3278 screen, and a conventional DOS screen. The 3270-PC is connected to an IBM 5218 letter-quality printer. The sample application is fairly simple: a BASIC program will be used to manage a series of API calls that extract data that IMS displays on the 3270-PC monitor and write that data to the PC disk.

figure 2 is an IBM MVS host system running IMS DB/DC (information management system database/data communication). IMS is a transactional database system for IBM mainframes. The 3270-PC in the figure is displaying two windows: an emulated 3278 screen, and a conventional DOS screen. The 3270-PC is connected to an IBM 5218 printer.

The sample application is fairly simple. The operator of the 3270-PC needs to produce several form letters on the IBM 5218 printer. Most of the text in these form letters is constant; only items such as names and addresses change. The names and addresses are stored on the mainframe in an IMS database. The operator can run an IMS transaction (program) that displays the needed information on the 3270-PC monitor. This does not help him, however, because the terminal itself cannot merge data into a typed document. (In the past, this required the operator to

write down the names and addresses from the screen and re-key them into a document through a microcomputer-based word processor.)

This situation presents an ideal opportunity for the 3270-PC API. A BASIC program is used to manage a series of API calls that extract data displayed by IMS on the 3270-PC monitor and write that data to the PC disk. The BASIC program performs the following steps to accomplish the task:

1. Use function 10 (QUERY SESSIONS) to get the session name of the host 3278 session.
2. Use function 1 (CONNECT) to establish a logical connection between a host session and the BASIC program.
3. Prompt the operator to input a record key. This key is used by the application to access the required name and address information from the IMS database.

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4. Use function 3 (SEND KEY) to type an IMS command on the connected host session. This command requests that an IMS format be displayed on the 3278 session screen.
5. Use function 3 (SEND KEY) to type the record key into the IMS format and press the Enter key. This causes IMS to access the database, retrieve the pertinent information, and, finally, display the information on the 3278 session screen.
6. Use function 8 (COPY STRING) to copy the needed information from the 3278 session screen into a variable in the BASIC program.
7. Finally, the BASIC program uses conventional DOS file I/O to write the name and address information into a sequential merge file on the 3270-PC's hard disk.

After the BASIC program finishes running, the necessary information is stored on the 3270-PC's hard disk. The 3270-PC operator now can use a word

processor to merge the data from the hard disk with a predefined form letter and produce letter-quality final documents on the 5218 printer.

The API functions are available to any program, both commercial and user-written. Although unlikely until the 3270-PC is more widely used, a product such as Symphony or Framework could be modified by its vendor to include additional macros that would permit it to access the API functions of the 3270-PC Control Program. API calls then would allow a spreadsheet to "press the keys" on a 3278 terminal session and accept data from the mainframe directly into the spreadsheet. IBM's own host 3270-PC file transfer utility is an example of a 3270-PC program that uses the API functions for file transfers.

The High Level Language Application Program Interface is not a typical PC software package, most of which offer fixed solutions to specific problems. The API, by contrast, equips the pro-

grammer with powerful means to solve a range of problems calling for 3278/79 communications. The 3270 API functions enable the programmer to create customized interfaces between the 3270-PC operator and the control program. Although it is not the ultimate answer to micro-to-mainframe communications, and in particular it is *not* recommended for performing large file transfers, the High Level Language API creates a link between the 3278 terminal and the PC, which were not originally designed to work together. 

IBM High Level Language Application Program Interface 1.2: \$130

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John Singer supervises the information center at The Brown Group in St. Louis, Missouri.

LISTING 1: FINDLIM.BAS

```
10 REM Interpretive BASIC Sample program
20 REM 1753180 3270PC High Level Language Application Program Interface
30 REM (C) Copyright IBM Corporation 1984
40 REM ***** INITIALIZATION CODE *****
50 DEF SEG = 0 'LOOK AT LOW MEMORY
```

```
60 INTR = &H45 'INTERRUPT 45 FINDS LIM
70 SEGM = 256*PEEK(INTR*4+3) + PEEK(INTR*4+2) 'GET SEGMENT POINTER
80 BLIM = 256*PEEK(INTR*4+1) + PEEK(INTR*4) 'GET PGM OFFSET POINTER
90 IF SEGM < > 0 THEN 110
100 PRINT "BASIC LANGUAGE INTERFACE IS NOT INSTALLED": END
110 DEF SEG = SEGM 'SET THE SEG FOR BASIC LIM
120 REM ***** END OF MANDATORY INITIALIZATION *****
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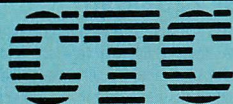
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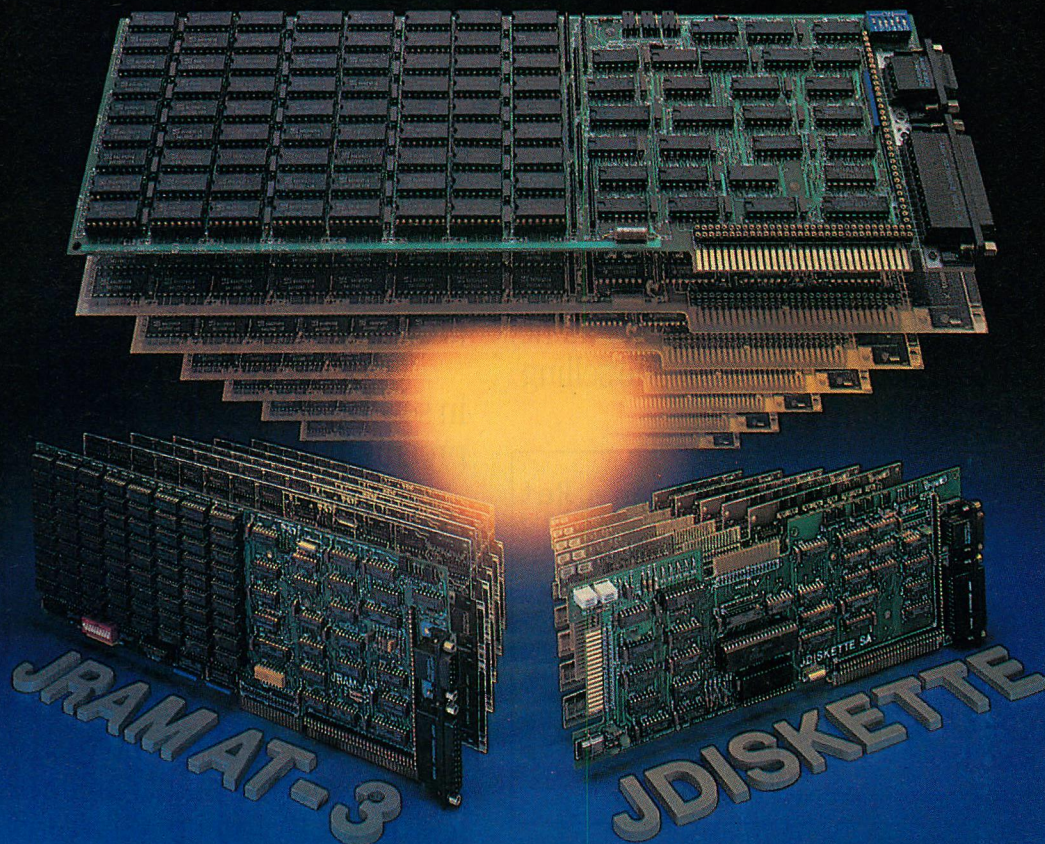


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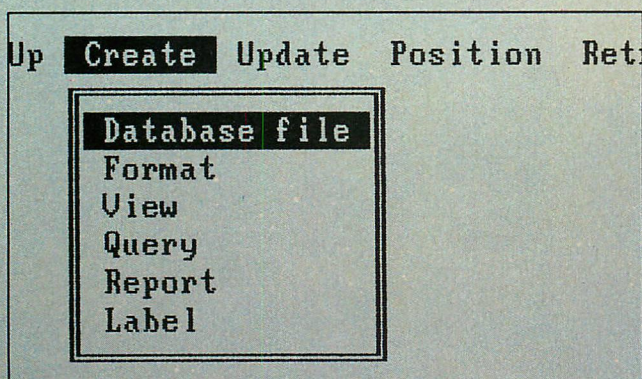
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- Combine with .OR.
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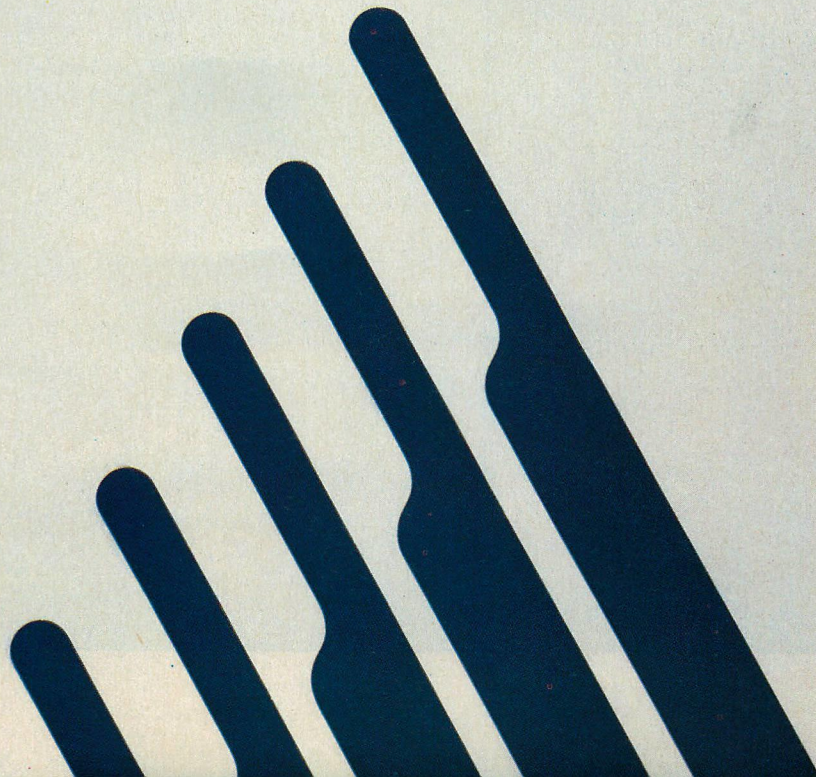
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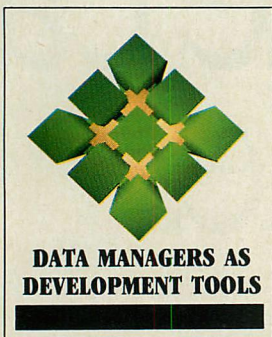
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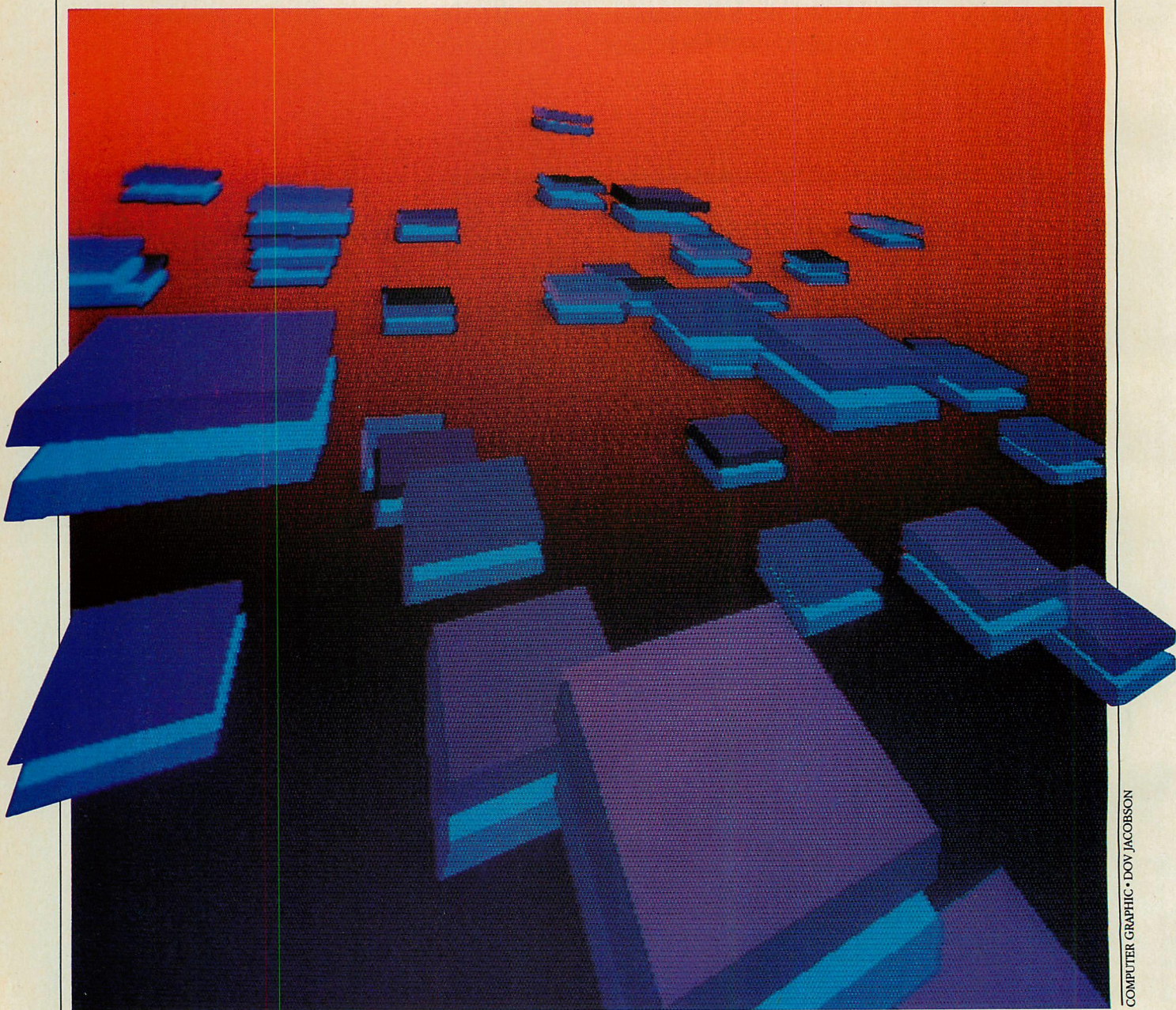
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Q-PRO4, from Q-N-E International, brings a forms processing approach to data management in both single and multiuser environments on multiple operating systems. The program is particularly appropriate for business applications that require a highly controlled user interface with familiar office forms. These applications typically mix retrieval of information by a reference, such as product number or company name, with sequential retrieval of information, such as inventory transactions. Applications in such environments revolve around well-defined transactions and require predefined reports to bring related information together periodically.

Database management requiring the ad hoc creation and manipulation of data storage formats, spreadsheet-like row/column relations, or word processing is not well-suited for Q-PRO4. It is therefore a product that is most appropriately used by applications developers rather than by end users as an information retrieval tool.

Q-PRO4 combines a data entry language with a sophisticated report generator and offers an optional query capability called Q-QUERY. The total package consists of an applications editor, a file descriptor generator, the runtime interpreter, a report generator, and the report processor. Several support utilities complete the development system.

Q-PRO4 can be configured to suit multiple hardware environments in addition to the IBM PC. It provides source code portability between 8- and 16-bit operating environments and single- or multiuser applications. The program works with either a floppy-disk-based system or a hard disk. It requires 128KB of memory and will use memory up to 192KB. The program is not copy

protected. Memory-resident applications such as Borland International's SideKick are compatible with Q-PRO4.

As shown in the accompanying sidebar, Q-PRO4 is priced separately for development and runtime systems and for single- and multiuser operating systems. Since the introduction of its basic forms processing program called Quic-N-Easi in 1981, Q-N-E International has shipped Q-PRO4 to more than 10,000 sites. Most customers are professional developers who support applications in vertical markets.

APPLICATIONS DESIGN

The heart of Q-PRO4 is the program QNE.EXE, which interprets format files that have been created with the format builder program. Understanding the interaction between QNE.EXE and format files is essential in order to create effective Q-PRO4 applications.

A format file consists of three interrelated parts: the background, program code, and table definitions. The format background is the developer-defined screen image on which user interactions take place. Q-PRO4 supports line drawing using the PC extended character set, including intersecting Ts and true corners. Otherwise, the format background consists of display text.

Within the format background are screen data fields, which are the principal areas for displaying data and the only data input areas available to the applications user. Each field is defined by a name (which can be comprised of up to ten characters), a length, row and column coordinates, and a wide variety of display/editing attributes. The type of data that are entered can be restricted to alphabetic, alphanumeric, or numeric characters only. After the user enters a value, the field either can retain the val-

ue, thus providing automatic duplication for the next record, or the field can be cleared. Invisible fields also are permissible (these can be especially useful for passwords).

A fill character can be defined to force the filling of unentered space in the field, and a display method controls whether data are centered or left- or right-justified. In addition, attributes control whether the field is display-only, whether entry is required, whether the user must completely fill the field before exiting, and whether, when the field is full, the cursor automatically moves to the next field or the user must press the tab key to exit.

While these attributes bring a reasonable level of data entry control to the Q-PRO4 application, it is the field procedure, the procedure to be invoked each time the operator exits the associated screen data field, that enables absolute control of data entry and sequencing of form processing. The field procedure can perform extended validity checks on the data, do calculations, retrieve or store data from the data files, and control which screen data field is processed next.

The remainder of the Q-PRO4 format file is made up of Q-PRO4 program code and table definitions. For each screen data field a program procedure can be named to run when the field is processed. These procedures can act on the data entered into the field and have full control of the Q-PRO4 data files; they have access to all the resources of the Q-PRO4 environment, including the data in any of the screen data fields, and to variables, registers, tables, and other procedures. They have the ability to chain to other Q-PRO4 format files or to run other programs via DOS. Much of a Q-PRO4 program is run through the

format data fields on a field-by-field basis. This has enormous implications in terms of the user interface.

In addition to tying procedures to screen data fields, the developer also can write standard procedures (LOAD, ENTER, ERROR, BREAK, and KEY0 through KEY20) that are linked to forms processing functions themselves. The LOAD procedure, executed automatically when the format file is first used, usually opens files, defines variables, and performs other chores in preparation for processing the form data. The ENTER procedure, executed when the Return key is pressed, usually acts on the form as a whole—for example, to update a database file.

Error handling is facilitated through two procedures: the BREAK procedure, executed when the Ctrl-C key combination is pressed, and the ERROR procedure, executed when a trapable error occurs. The KEY0 through KEY20 procedures, executed in response to 21 program function keys, can be used to select from menus defined as the background display and can allow the developer to set up a consistent user interface across the entire application. For example, F10 can be used to exit to the main menu. The function keys thus take on a role as user-initiated software event handlers. This aspect of Q-PRO4 also has enormous implications in terms of the user interaction.

Although only one screen is available as the background of a Q-PRO4 format file, any number of help screens can be invoked from Q-PRO4 procedures, and they can be related as a series of screens. The number of the current screen data field is available to a procedure for processing. Thus, a single function key can be used to display a help screen related to the current screen field at any time during data entry. A help screen is a format file, which is built with the format builder utility, and is background text only. It has no screen data fields or procedures.

The procedure area of the format file also can contain tables. Q-PRO4 tables are data constructs that can be referenced by a name. They consist of arrays of data items, with each row containing one or more items separated by commas, up to a total of 80 characters per row. Tables can be used for multiple purposes within Q-PRO4, including data validation, value retrieval, and program control. Table elements can be assigned values with program commands, so information read from a disk file can be stored into a memory-resident table for use with the format file.

DATA STORAGE

Q-PRO4 supports four types of data files. Random access files contain fixed-length records and can be accessed by record number in any order. Multikey indexed sequential access method (ISAM) files are similar to random access files, but have internally stored index keys in place of the record number overhead of random access files. Both random access files and ISAM files are supported by a Q-PRO4 file item description (FID) file. The FID file acts as a data dictionary and contains information about the record structure so data can be referenced by field name. Q-PRO4 supports sequential output and input files in both ASCII stream format and comma-delimited format. These two formats can be used to share data with other programs, such as those written in Microsoft BASIC.

In general, comma-delimited files are used for data interchange with other programs, sequential output files are used for disk storage of reports or transaction logs, and sequential input

Much of a Q-PRO4 program is run through the format data fields on a field-by-field basis.

files are used to import data from other programs or to process transactions from another system. Records in random access files can be accessed quickly and used to create transaction records that may be processed later to update the ISAM master files.

The ISAM file, in particular the ISAM file defined by a Q-PRO4 FID file, is the primary storage method used by Q-PRO4 applications. File item descriptor records are built and maintained with the utility program, FID. The FID utility allows record layouts and ISAM indexes to be freely changed without immediately altering the associated data files. This provides only a limited amount of freedom, however, and changing FID files apart from the data files merely facilitates the development process. An added benefit is that multiple data files can be described by a single FID file. One application of this is to have separate files for each month's transactions, yet have one transaction file description. The FID files allow manipulation of data by field name for the Q-PRO4

query and report generator programs as well as Q-PRO4 applications themselves.

But beware. Any change to an FID-described file must be accompanied by a reorganization of the data file to suit the new description. Changing the structure of a Q-PRO4 data file is a time-consuming process not to be undertaken lightly. Any change to the actual data layout or the index keys requires that the data file be unloaded and then reloaded. Unloading and reloading are done with the QFILE file builder utility, and the ISAM keys are created with the REORG file reorganization utility. In compensation, FID-described ISAM files have their indexes stored internally with the data file, and all indexes are available to any program using the data file. All indexes are maintained automatically by Q-PRO4 as records are changed or added. Unfortunately, no temporary sort or ad hoc index capability is provided within Q-PRO4.

Although the Q-PRO4 data structure is rigid, the capacities are generous. Any number of fields can be described for a record, and fields can overlap so that groups of data can have multiple definitions. Fields also can be replicated and processed as arrays. Fields can be either numeric or string type, and each field can have a length of 1 to 256 bytes (per repetition; up to 65,000 repetitions per field). Nine ISAM keys can be defined in a file item descriptor record, and each key can be composed of up to 18 fields, which do not have to be adjacent. Q-PRO4 supports both exact key and partial key look-up for data files, and the language is precise in distinguishing between the two.

Keys are referenced by number. The first key of a file is the primary key and, thus, the default access key. A record's primary key must be unique. Duplicate keys—that is, records with identical values in the fields that make up the key—are supported for the other eight keys. To force uniqueness for the primary key, a record number field can be added to the record. This discovery is left up to the applications developer. Figure 1 shows the FID file for the Author database from the sample application developed by *PC Tech Journal* to evaluate data managers (for a complete explanation of the sample application, see "Sample Application Specifications," August 1985, p. 48; also available from PCTECHline).

Q-PRO4 APPLICATIONS

A Q-PRO4 application is made up of a network of format files and the data files on which they operate. Q-PRO4 pro-

FIGURE 1: *Author File Description*

Quic-N-Easi File Item Description						
File AUTHOR.FID						
TYPE: INDEXED						
RECORD LENGTH: 335						
DATA LENGTH: 302						
FIELD	ALIGNED	TYPE	START	LEN	REPS	DESCRIPTION
LAST_NAME		X	1	18	1	AUTHOR'S LAST NAME
FIRST_NAME		X	19	12	1	AUTHOR'S FIRST NAME
ADDRESS		X	31	20	1	STREET ADDRESS
CITY		X	51	16	1	CITY OF RESIDENCE
STATE		X	67	2	1	STATE OF RESIDENCE
ZIP		X	69	5	1	ZIP CODE OF RESIDENCE
W_PHONE1		X	74	3	1	WORK PHONE, AREA CODE
W_PHONE2		X	77	3	1	WORK PHONE, EXCHANGE
W_PHONE3		X	80	4	1	WORK PHONE, SERVICE NUMBER
H_PHONE1		X	84	3	1	HOME PHONE, AREA CODE
H_PHONE2		X	87	3	1	HOME PHONE, EXCHANGE
H_PHONE3		X	90	4	1	HOME PHONE, SERVICE NUMBER
SS_NUMBER1		N	94	3	1	SOCIAL SECURITY NO. REGION
SS_NUMBER2		N	97	2	1	SOCIAL SECURITY NO. YEAR
SS_NUMBER3		N	99	4	1	SOCIAL SECURITY NO. SERIAL
BIOG		X	103	50	4	BIOGRAPHY

In this file description the fields are defined as either alphanumeric (X) or numeric (N). Notice that the biography field is defined as a repeating field that is 50 characters long for a total effective length of 200 characters.

cedures have the ability to run other DOS programs and then return to the invoking format file. Running external programs from Q-PRO4 integrates Q-PRO4 database maintenance applications with ad hoc queries using the optional query program and with reports written with the Q-PRO4 report generator. Altogether, these programs provide a complete data management system.

The *PC Tech Journal* sample application was developed as a hierarchy of menu formats leading to data record maintenance formats or reports, queries, or entire database functions. Even the latter, when accessed via a format file, presents the user with a screen that describes what will happen if the user runs the underlying program and presents an option either to perform the task, which may be a database load, or to exit to the previous menu.

The report and query processors can be controlled from a Q-PRO4 application via parameters. Control information passed to the report program is limited to which report to run, the report date, the starting page number, and similar runtime data. The query program, in contrast, can be passed an entire sequence of commands and also made to read a control file from the disk. Such a control file is a sequential file created from a Q-PRO4 application, with text that defines what the query is to do. A Q-PRO4 application can generate and run application-specific queries without requiring the user to interact with the

query program itself. Consequently, the user interface can be entirely under the developer's control. Neither the query program nor the report generator is suitable for novices users.

Q-PRO4 procedures consist of statements in the Q-PRO4 applications language organized for editing convenience as a sequence of paragraphs or groups of statements. Programs and tables can consist of merely a few statements each or multiple paragraphs of an indefinite length. Paragraph constraints are described below.

Procedures are bound to Q-PRO4 format files and must operate within the constraints of that environment. As such, no global Q-PRO4 procedures are available. The PROC OPEN_AUTHOR procedure cannot exist as a program module independent of a format file, and because only one format is in operation at a time, it is accessible only to the format file in which it resides. Any application-specific functions that are required for several format files, therefore, must be repeated for each format file requiring them. Whether or not this is a problem depends on the application and the discipline with which the developer has approached this aspect of Q-PRO4. PROC OPEN_AUTHOR may be a logically independent program function that can reside anywhere within the paragraphs that make up the format file procedure. The developer can, however, anticipate a maintenance problem with PROC OPEN_AUTHOR, define it to



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be paragraphs 1030 through 1050, and reserve those paragraphs for that procedure in each format file in an application. Because the format builder utility allows paragraphs to be moved between format files (preserving their paragraph numbers), this program maintenance problem can be mitigated.

The very nature of Q-PRO4 programs tends to produce fairly short procedures. The entire author database load procedure in the sample application, in which each field is handled separately, requires less than 50 statements in four

successive paragraphs. The first paragraph of the same format file consists of 18 statements, which define the format initialization procedure, and four separate debugging procedures (that can be invoked by function keys).

Q-PRO4 language statements are typical of other fourth generation applications languages. A few words do a lot of work, and the language is a mix of procedural and nonprocedural statements. Procedure, table, and variable names as well as program labels can have up to ten characters and can use the under-

line character for clarity. Each statement in this language is of the form:

{label} verb <operands> {modifiers} {error branch}

Elements shown in braces are optional.

A typical Q-PRO4 procedure is presented in figure 2. This is a fragment from the procedure written to perform a benchmark—changing all CO state codes to CL (see table 1). The procedure KEY1 is invoked when the user presses F1 to start the benchmark. The procedure opens the author database file and switches to the state/zip code key order (F2). It then positions via the POSN command to the first of the CO state entries using a partial key, because the zip code portion is not known. After a partial key search is made on a key that does not exist, the file is positioned at the record having the next highest value of the key, so the State field of the record is checked after reading the record to verify that CO was found. Because the key is being changed, the old record and its index entries have to be deleted with the FREE statement. The key field is then changed from CO to CL, the record is written back to the file, and the key entries are created automatically. This process repeats until the partial key match fails. Portions of this procedure are not intelligible without an understanding of how Q-PRO4 data items are referenced.

Q-PRO4 statements can reference six kinds of data items. Shown in the procedure fragment in figure 2 are the string constants CO and CL. Constants, or literals, can be strings, numbers, or control characters. A name such as **what_todo** can refer to either a screen data field or a declared variable. Screen data fields are defined with the format file, as described above. Variables must be declared with the VRBL statement and can be either string (1 to 255 characters) or numeric (1 to 20 digits). They have both a name and a dimension (1 to 65,000). Variables can be defined until memory is exhausted, which is a distinguishing feature of Q-PRO4. Both screen data fields and variables are local to the format file in which they reside. Variables are not preserved across a chain to another format file. In figure 2, **what_todo** is a screen data field. Moving **Author database mass change** to it causes the message to appear, centered, on the screen.

Fields for a data file are demarcated with the & prefix, the field name, and the file number in square brackets. OPEN declares the data file, AUTHORDAT, and its associated FID file,

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FIGURE 2: *Program Fragment*

```
PROC key1
  BELL
  MOVE "Author database mass change" TO what_todo
  * open the author database as #1...
  OPEN "author.dat" USING "author.fid",1 :no_file
  KEY 1 USING 2
:read_loop
  POSN 1 TO "CO" RELATIVE
  READ 1 NOADV :bad_read
  IF &state[1] <> "CO" GOTO eof
  FREE 1
  MOVE "CL" TO &state[1]
  WRITE 1 NOADV :bad_write
  GOTO read_loop

:eof CLOSE
  BELL
  CLEAR what_todo
END

:no_file ERROR "Unable to open 'AUTHOR.DAT' file -- press ESC"
END
```

This typical Q-PRO4 procedure is a fragment from the procedure written to perform benchmark 4, which involves the changing of all state codes from CO to CL. The procedure KEY1 is invoked when the user presses function key 1 in order to choose this benchmark from a menu.

TABLE 1: *Benchmark Results*

BENCHMARK TASK	TIME (secs)
Add 900 records to an empty database	606
Index database on two fields (7 bytes)	—
Document and tally codes from one field	176
Mass change of one field (28 records of 900)	90
Extract selected records to create a test file	6

These results, which are much slower than the other data managers tested so far in this series of reviews, can be traced to Q-PRO4's inefficient methods of ordering the data on the disk. Unfortunately, they do not reflect the ease and speed with which screens and menus are processed by this data manager.

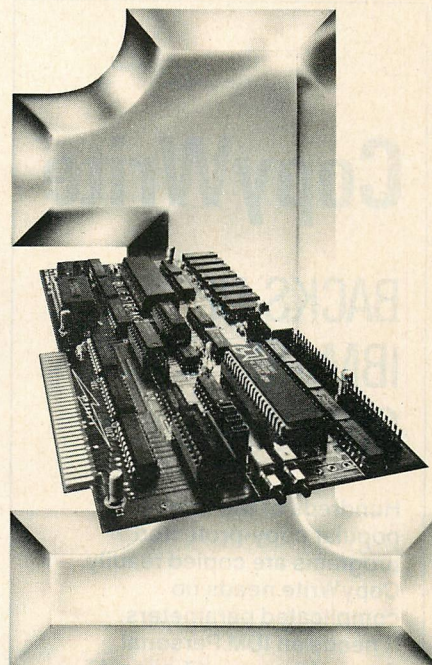
AUTHOR.FID, as file 1. Thus, &state[1] refers to the State field of file 1.

All variables and field elements in Q-PRO4 are treated as arrays of one or more elements. A reference to the second element of a state array in file 1 would be &state[1,2]. Because state in the Author database is not an array, a reference to it as &state[1,1] would be syntactically correct but unnecessary.

Registers in Q-PRO4 are predefined data items demarcated with the # prefix. #N0 through #N9 can hold numeric values up to 20 digits. #S0 through #S9 are string registers and can contain strings of 0 to 255 characters. #B0 through #B9 are Boolean (true/false) registers. Five read-only registers make aspects of the Q-PRO4 environment accessible to the program. These are the error number register (#E), the current screen field number (#F), the key-out register (#K), and the

line counter (#L) and page number (#P) registers. The #F register allows one function key both to handle help requests and to provide field-specific help depending on the current field number, and the #K register informs the program of how the user left the current screen field. Unlike screen data fields and variables, registers are preserved across a chain operation to another format file.

A label identifies a location within Q-PRO4 statements and is used for changing program flow. Most Q-PRO4 statements that can generate an error condition can handle the error by transferring control to another section of the format file. The error branch of a Q-PRO4 statement points to a label; should an error occur in executing the statement, control is resumed at that label. The listing fragment in figure 2 relies on either a read error occurring (in



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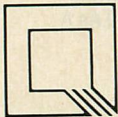
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QPRO-4

which case the program resumes at `:bad_read`) or a state other than `CO` being read (`IF &state[1] <> "CO"` `GOTO eof`) to terminate the `:read_loop` section of code. Again, the `#E` register makes the specific error code available so that appropriate action may be taken.

Other than the statement-specific error trap, a regional error procedure can be specified with the `ERRTRAP` statement (similar to a BASIC's `ON ERROR GOTO xxx` statement), and a standard procedure `PROC ERROR` can be defined for the entire format file. With these capabilities in the language, only a statement that cannot be interpreted, a syntax error, generates a non-trappable error. Runtime errors or user interaction errors can be handled completely via methods designed by the developer to suit a particular application.

Block control structures available within Q-PRO4 include `BEGIN`, `BEGIN WHILE`, `BEGIN UNTIL`, and `BEGIN IF`. `BEGIN` statements are concluded with an `ENDBEGIN` statement. Loops can be controlled with `FOR/ENDFOR` statements. Conditional statements take the form `IF <condition> THEN <statement>`. `BEGIN IF` structures take the optional statements `ELSE` and `ELSE IF`, which support nested `IF` logic. Complex expressions are supported by the `IF` statement, including 11 conditional operators (`EQ`, `NEQ`, ...) and the ability to connect multiple conditions with `AND`, `OR`, and parentheses to determine evaluation order. Another form of `IF` is accepted for testing the Boolean registers—for example, `ON #B1 SET <statement>`, which executes the statement if the Boolean register `#B1` is set.

Modularity in a Q-PRO4 application is implicit in the correlation of procedures with function keys and screen data fields. In addition, one procedure can `CALL` another as a subroutine (which must `RETURN`), up to a nesting limit of 20 `CALL` statements. `GOTO` statements provide branching functions themselves, and both `CALL` and `GOTO` support a table look-up function for computed control transfer.

Numeric accuracy within Q-PRO4 is assured up to 20 digits, and internal calculations are performed as real numbers with about 30-digit significance, truncated to 20 digits when results are stored in fields, variables, or registers. Arithmetic operators include `ADD`, `SUB`, `MUL`, and `DIV`. Alternatively, the `CALC` statement can be used for other than simple expressions. The `ROUND` statement determines the number of significant fractional digits for a data item, and the `$INT` construct allows conversion of

real numbers to integers. Q-PRO4 has functions that return natural logs and e raised to the x power (`ACCURACY` can be set for the latter). Conversions between numeric and string data are accomplished with the `MOVE` statement.

String operations are performed primarily with the `MOVE` statement. It is used for moving entire strings, substrings, and blank-trimmed strings from one data item to another. It also can append one string to another. The `CONCAT` statement handles multiple string concatenation expressions, while `INSTR` searches a string for a substring's position. `LJUST` left-justifies text within a string, `RJUST` performs right justification, and `CENTER` centers text within a string. The `SIZE` statement places the size of a string into a data item.

String manipulation within other Q-PRO4 statements is not possible during their evaluation; instead, a string must be manipulated as a data item to prepare it for other statements. The `PUT` statement, for example, transfers a data item to a sequential file or printer buffer and cannot handle an expression in place of a discrete data item. The `PRINT` statement, which displays one or more data items on the screen, is able to handle numeric data without conversion to string, but cannot perform string operations. String data items must be prepared prior to using `PRINT`, generally in string registers.

One powerful string manipulation capability of Q-PRO4 is the `EDIT` statement, which can format numeric data into a string according to an editing picture. Similar to formatting statements used in other languages, `EDIT` allows leading asterisks, floating dollar signs, commas, and fixed decimal points. Its string-to-numeric conversion counterpart is the `UNEDIT` statement.

Several Q-PRO4 statements deal specifically with screen data fields. The `LOCK` statement overrides the `MAY ENTER` attribute specified at field definition, making entry of data impossible until the field is `UNLOCKed`. `CLEAR` places blanks in a named field, while the `MOVE` statement places data into a field for display. Data entered by the operator can be operated on by using the field name. `RESUME` returns control to the user with the cursor remaining in the current screen field; it is generally used in a key procedure. `NEXT` names a different field to be processed instead. The `HOME` statement selects the first screen field for input. `END` returns control to the operator at the field indicated by the edit control key pressed to leave the field.

HOME CLEAR selects the first screen field for entry and blanks out all UNLOCKED fields (those that can be entered) on the screen. FILL places a literal character such as a period in all UNLOCKED fields and can indicate the size of fields at the start of data entry.

Information can be placed on the screen in areas other than screen data fields, overriding the format background. CURSOR places the output position, while PRINT performs the actual display. The operator can receive audible feedback with the BELL statement.

Q-PRO4 has a full set of commands for file handling. Full file operations are possible with the RENAME, ERASE, and FCOPY statements. GET and PUT perform field-to-buffer read/write operations for sequential files. READ and WRITE act on any type of file and take a NOADV argument to suppress the default positioning

to the next record. BACKSPACE allows an ISAM file to be positioned to the previous record in index order. POSN locates a record by its ISAM key and can be either exact (the default) or RELATIVE (a partial key). For applications that require information to be located according to nonindexed criteria, FSEAR allows a record to be found based on a search expression. The file is still processed in the current index order with FSEAR. FREE erases a record and releases its key information. KEY is used to select the current key number for an ISAM file. SECURE causes all memory buffers to be flushed to disk for applications (or developers) that must minimize the possibility of data loss from hardware or operator malfunctions.

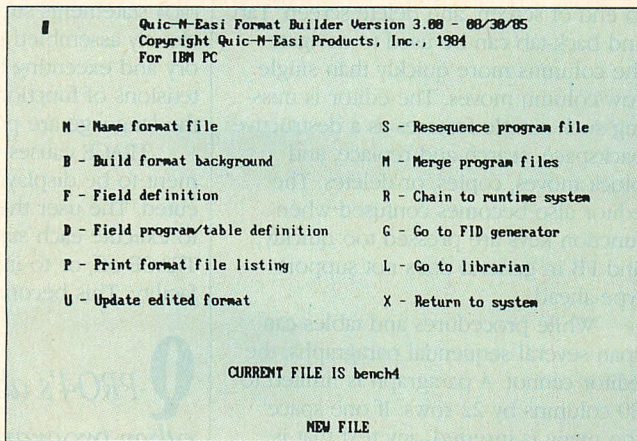
Q-PRO4's multiuser commands include RLOCK and RUNLOCK for record locking and unlocking. The default number of locked-record retries is set with LRETRY. In general, Q-PRO4 requires the developer to perform error recovery for locked records.

THE DEVELOPMENT PROCESS

The nature of Q-PRO4 format files tends to organize the development process in a modular way. Format files usually

have a single purpose: a menu dispatch, a record maintenance activity, or a database manipulation/calculation/report function. Generally, each format file uses the background screen and screen data fields to conduct user dialogues. Planning which module will perform which tasks is a natural step of working with Q-PRO4. Each function is presumed to be started by an invoking menu and to return to that or another menu upon completion of its tasks.

PHOTO 1: Format Builder Menu

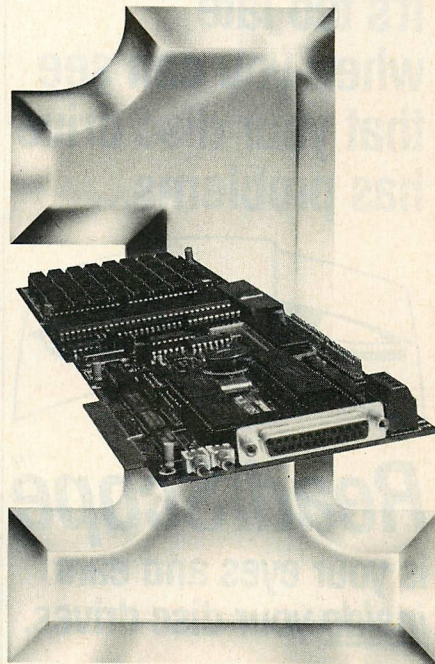


A Q-PRO4 format file is built by performing functions N, B, F, D, and U—in that order. Then the application can be tested immediately by selecting option R.

Format files are the building blocks of an application. Interdependently conceived, yet independent in function, each file can be developed on a stand-alone basis. One beauty of Q-PRO4 is the applications developer's ability to work with one module at a time. Format files are created and modified using the format file builder utility FB.EXE. Similar to other members of the Q-PRO4 family, FB is composed of related functions united by a menu (see photo 1).

N is pressed to enter the name for the format file to edit, B to construct the background screen, and F to define the screen data fields. The procedure and table portion of the format file is defined with D. Pressing U records the work on the disk, and R chains to QNE.EXE and processes the format file. FORMLOAD within a format file causes QNE.EXE to chain back to the FB program instead of to DOS when a SYSTEM statement is performed. This sequence of events, which is the normal development process, allows the developer to move between FB.EXE and QNE.EXE quickly, alternately editing and running the format file.

The FB editor is used for both background screens and procedure



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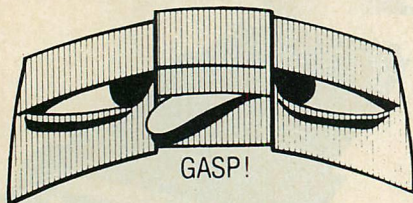
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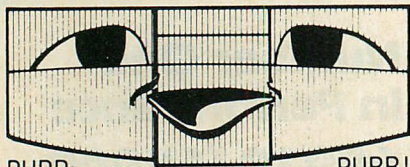
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QPRO-4

table definitions. A utility is provided to create a format file from a standard ASCII text file produced by other editors; however, once a program is in the Q-PRO4 format it must stay there; using the FB editor is virtually unavoidable.

The FB editor is a four-function screen editor that can move the cursor, insert, delete, and save. It supports line and character insert, but cannot split a line, join lines, or enter text in insert mode; pressing the INSERT key puts a blank space at the cursor. Delete functions are more extensive, with delete character, delete to end of line, delete to end of screen, and delete screen. Tab and back-tab can be used to navigate the columns more quickly than single row/column moves. The editor is missing such simple features as a destructive backspace, search and replace, and block moves, copies, or deletes. The editor also becomes confused when function keys are pressed too quickly, and FB in general does not support type-ahead.

While procedures and tables can span several sequential paragraphs, the editor cannot. A paragraph is limited to 80 columns by 22 rows. If one space too many is inserted, any text that is pushed off the screen to the right is gone. Likewise, a line that scrolls off the screen is gone. Neither horizontal nor vertical scrolling is supported. The editor does allow a paragraph to be abandoned without saving it.

The FB editor also allows paragraphs from other format files to be merged with the current file. Paragraph numbers are preserved during transfer, and one paragraph can be brought up for editing and then immediately saved as a different paragraph.

The Q-PRO4 interpreter is not case-sensitive and ignores extra blanks and comment lines while running. The backslash character is reserved to designate a statement continuation on the next line. Altogether, Q-PRO4 statements can be stylized to suit the developer's taste. Memory-resident editors are compatible with the Q-PRO4 program family. Given the typically short nature of Q-PRO4 procedures and the modular style of assembling a Q-PRO4 application, the limitations of the editor are not overly severe. Once the user has adjusted to the FB editor, its effectiveness becomes apparent. Q-N-E is working on remedies for FB's shortcomings.

Several tools for program development are available. When nontrapped errors occur during the execution of Q-PRO4 programs, the interpreter describes the error and displays the pa-

ragraph number and offending statement. Pressing Esc (with FORMLOAD in effect) causes Q-PRO4 to chain to FB. With a few keystrokes the offending paragraph can be recalled and corrected. A few more keystrokes saves the file and starts the interpreter running the new version. Cycling between interpreter and editor is very quick.

DEBUG allows most all aspects of the Q-PRO4 environment to be examined and changed—even memory addresses (in conjunction with a DEFSEG statement), so that the interface to memory-resident programs can be debugged. Q-PRO4 statements support loading previously assembled programs into memory and executing them; therefore, extensions of functionality beyond that of the language are possible.

TRACE causes each Q-PRO4 statement to be displayed before it is executed. The user then decides whether to execute each statement, to turn TRACE off, or to invoke the DEBUG facility. This becomes exceptionally use-

Q-PRO4's ability to run other programs and return to the same format file extends its application control aspects beyond the scope of the interpreter itself.

ful when combined with a function key procedure (for use with menus) or with the standard BREAK procedure. In this way, a program can be interrupted and diagnosed at any time. Data items can be examined and modified, then the program can be resumed.

During development of the sample application for this article, these features were used to good effect. PROC BREAK was defined as DEBUG followed by END. PROC KEY0 (the procedure for the F10 key) was defined as CHAIN <previous menu>, which is the normal path exit of the format file. PROC KEY12 (Shift-F2), the development path exit, was defined as SYSTEM (with FORMLOAD in effect in case of syntax errors); pressing Shift-F2 exited to the FB program. PROC KEY14 was defined as NOFORMLOAD followed by SYSTEM. This set of statements allowed the user to exit the format file directly to DOS simply by pressing Shift-F4.

While these examples illustrate the use of function key programs for development purposes, they can be used with equal effectiveness within the application itself. The user can choose between exact keys or partial keys to the file by selecting a function key. Index key values are entered in the appropriate data fields, then a function key is pressed for FIND RECORD. If no exact match exists, a function key is pressed for FIND NEAREST RECORD. By pressing a different function key, the user switches access keys to the file.

Q-PRO4's ability to run other programs and return to the same format file extends its application control aspects beyond the scope of the interpreter itself. The RUN capability binds the Q-PRO4 report and query programs with Q-PRO4 programs into a single user interface. The file maintenance utilities (to verify, rebuild, or recover files) also can be controlled in this way.

THE QUERY PROCESS

The optional query program, called Q-QUERY, provides for ad hoc information retrieval from Q-PRO4's FID-type databases. Output can be routed to the screen, the printer, or a disk file.

The query process starts with the definitions of the files to be used. Information for 12 databases, with 6 related databases each, can be retrieved. One of the 6 related data files is selected as the control file. Each file defined is assigned a logical name for the query. Its file name must be given along with its FID file and the default search key, which is used with the control file. A temporary sort order for the control file can be established by Q-QUERY and can reference multiple fields with mixed ascending and descending orders.

Next, a selection expression for the search is defined to designate a file as the control (primary) search file and give a logical expression for selecting its records. The selection expression includes complex expressions and references to fields in any database.

PC Tech Journal's sample application includes a query to determine which articles were received after the deadline for a particular magazine issue. The selection expression that is used to accomplish this search is:

SELECT article

```
WHEN volume EQ 3 AND number EQ 1
AND $JDATE(date_rcd) >
  $JDATE(deadline(issue)).
```

The selection command is simply typed on the screen without benefit of a form to fill in. The heart of the query is



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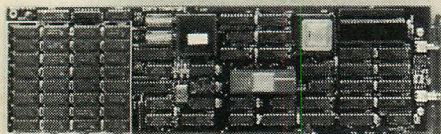
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QPRO-4

shown in figure 3, which is an annotated form of the Q-QUERY parameters that are saved on disk.

The display expression is defined as a list of fields and instructions for how they are to be displayed on the screen. It also is entered without a form to follow. Fields from any defined database can be used. Numeric fields can be arithmetically combined, and string fields can be blank-trimmed (%) and concatenated (++). \$JDATE is a Q-QUERY function that converts a string to a Julian date. Options in expressions include literal text (Author:), display column width, and display format criteria.

As many as 20 summary lines can be defined for a query. Each line consists of display text and a summary type: a count, sum, high value, low value, or average value. A selection condition can be defined for a summary line, so that record filtering (qualifiers) can be used in addition to the primary file's record selection conditions. The summary line's values are entered via a form, as shown below, for the sample query that sums up the number of editorial pages in a particular magazine issue.

Description: [Editorial pages:]
Type: [Sum]
Value: [edit_pages + list_pages]
Edit using: [1]

Edit using specifies the format of the computed summary value: integer, numeric (number of decimal places), or \$. In the sample application, the \$ editing specification did not work.

When query output is sent to the screen, Q-QUERY pauses after displaying each selection record. The summary can be viewed at the conclusion of the query. Queries can be saved in a disk file and recalled later. Query input can be generated as a sequential output file from a Q-PRO4 application. The Q-QUERY command line can include control statements that cause Q-QUERY to load and modify a stored query, run the query, show the summary results, and exit.

While the Q-QUERY program is straightforward and includes context-sensitive help, its blank-screen command input style is not for the novice. Its pattern-matching capabilities, which allow combinations of 14 special characters in string positions, are cryptic. The display editing expressions, such as that shown in figure 3, demonstrate the technical orientation of Q-QUERY.

THE REPORT GENERATOR

The Q-PRO4 report generator is especially well-suited for the transaction processing and master file updates that

**FIGURE 3: Annotated
Q-QUERY Parameters**

```
STATUS -- Printer: OFF
        Screen: ON
        Autohelp: OFF
        Report file: NONE

TITLE: PC Tech Journal Query #7

SELECT EXPRESSION:
volume EQ 3 AND number EQ 1
AND $JDATE(date_recd) > $JDATE(deadline(issue))

QUIT EXPRESSION: NONE

DISPLAY EXPRESSION:
"Volume " ++ volume(article) ++ " Number "
++ number(article) ++ " due "
++ deadline(issue):W40, " ",
title:W60,
" Author: " ++ %a_first_n ++ " ++ %a_last_n:W42,
" Coauthor: " ++ %co_first_n ++ " ++ %co_last_n:W42,
" ",
" Category: " ++ category:W40,
" Department: " ++ department:W40,
" ",
" Date received: " ++ date_recd:W40,
$JDATE(date_recvd) - $JDATE(deadline(issue)):
IW2" Days late: "

FILE DEFINITIONS:
-----DATA FILE-----
--Name-- -Data file- -FID file- Key
issue    issue.dat   issue.fid  1
article  article.dat article.fid 1
-----RELATED FILE-----
--Name-- -Key-- Key Expression
issue    1      volume+number

PRIMARY FILE: article
```

These parameters were defined to query the sample database for articles that arrived after deadline for volume 3, issue 1.

are required in many business applications. The program RG.EXE creates and maintains report specifications for the report processor REPORT.EXE. The relation between the two is similar to that of FB and QNE as editor and runtime system. RG is used by the applications developer while REPORT is used by the end user. RG has a function menu similar to the FB menu shown in photo 1. Like Q-QUERY, the user can run REPORT from a Q-PRO4 program.

The REPORT program can work with six files at once. Each file can have an acceptance expression that specifies qualifications for records from that file. The expression can include references to fields from any of the six files. Each file also can have a resort key, which provides a temporary index capability missing in the Q-PRO4 language.

A quick report facility within RG creates a full report specification for a single file. All fields (by default) or selected fields can be included. Once

created, however, the quick report specification works the same as any other; it can be edited, enhanced for multiple files, and rearranged. This is a good starting point for using the report generator, because it creates a simple report that works correctly. Refinements can use REPORT's format and regional control capabilities.

The report generator follows the style of FB in several ways. The report layout itself uses Q-PRO4's full-screen editing. Unlike FB, horizontal and vertical scrolling are supported. The layout, which is essentially the format for the report, consists of line groups called *regions*, which are repeated according to the record selection and processing rules specified. Heading and footing regions are available, allowing REPORT to meet the report format requirements of the sample application.

Each region is clearly denoted on the screen during format editing, and the region name corresponding to the current cursor location is shown at the top of the screen. Cursor keys, tab, and back-tab are used to position the cursor during editing; function keys are used to scroll the editing window and invoke editing functions. To edit a region specification, for example, the cursor is moved to within the desired region and F10 is pressed. To edit a field specification, the cursor is moved to within the field, shown as asterisks on the screen, and F3 is pressed.

Within the region text are fields, similar in function to FB's screen data fields. Each field has a name, length, type (numeric or alphanumeric), and attributes. The display attributes include justification (left, right, or center) and editing criteria (including various kinds for numeric and alphanumeric, as well as Julian date conversion). An invisible display attribute allows a field to be calculated within a region, but not to appear in the region's printed lines. Other field attributes control whether or not the field causes a report break when it changes value, which of 255 accumulators its value should be added to, and which field of which file should be updated, if any. The value expression of a field determines how it is to be calculated and can reference constants, literals, predefined variables, region fields, accumulators, or fields from any data file. Both arithmetic expressions and string expressions are acceptable. An unusual feature of the value expression is its ability to accept conditional logic for simple disjunctions (if *X* then calculate *A*, else calculate *B*). The latter can be used to count an inventory transac-

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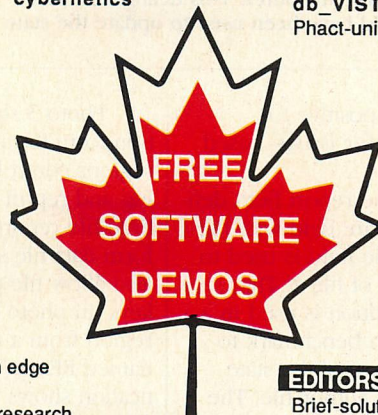
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PHOTO 2: Report Field Definition

```

Field Definition

Field name [new_state] Length [2]
Field type [X] (N=Numeric,X=alphanumeric)
Field justification [L] (L=Left,R=Right,C=Centered)

Break on this field (Y/N)? [N]

Add to accumulator [ ] (blank=none, else 1 through 255)

Update on file [1] (blank=none, else 1 through 6)
Update file field name [state]

Value expression
["CL"]

Edit criteria
[ ]

Press ENTER to update field definition      Press FUNCT 9 for help
Press FUNCT 8 to cancel changes

```

The definition of each field on the report includes a name, length, type, and display attributes. This definition of the "new state" field could have been used to update the state code from CO to CL.

PHOTO 3: Report Region Definition

```

Edit/Add New Region

Region name [READ]      # Lines [ ] (blank=to next region)

File # Key/Rec #      Delete record? Exact match? Next if
(1-6) (blank=next) (Y/N) (Y/N) end-file
[1] [ ] [ ] [ ] [*]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]

Region type [ ] (H=Heading, F=Footnote, blank=normal)
Region displayable (Y/N)? [N] Start at top of form (Y/N)? [N]
Next if no field or region break (PRINT) [ ] (*=end report)
Next if field break [ ] (*=end report)
Regional break condition
[ ]
Next if regional break [ ] (*=end report)

Press ENTER to update region definition      Press FUNCT 9 for help
Press FUNCT 8 to cancel changes

```

Report regions control the actual data file reading and the report output writing. This region, which is called READ, reads the contents of the author file; after each record is read, the PRINT region is processed.

tion amount value as positive for receipts and negative for issues, based on a transaction type.

Photo 2 shows the report field definition for the **new_state** field with the constant value, CL. The field is used to update the **state** field of file 1. The **new_state** field definition is used in a report that performs a benchmark to change each occurrence of the state code CO to CL in the Author file. The record acceptance expression for this report is **state(1)='CO'**. This method takes about twice as long to change the file as the Q-PRO4 program used in the benchmark timing, but it does yield the correct result and demonstrates an important feature of the REPORT program—selective updating.

Photo 3 shows the screen specification form for a report region. Report regions control the actual data file reading and report output writing. For multiple file reports, report regions perform data file synchronization. Regions also allow file positioning by alternate keys. In photo 3 the file handling region from a report is, appropriately, named READ. The file area of the specification shows that file 1 (the Author file) will be read sequentially until the end of file, at which point the report ends. As each record is read, the PRINT region is processed.

The form shows the other region specifications and has fields that direct the REPORT program to other regions based on several conditions. Next if no

field or region break names the region to be processed next under normal file processing conditions. When a field defined within the region as a *break field* changes value, the Next if field break region is processed. The Next if regional break field names the region to be processed when an expression in the Regional break condition field is satisfied. The system registers for field or region expressions include the accumulators, current page and line numbers, end-of-file conditions for each of the six files, and the current date in string, numeric, and Julian date forms.

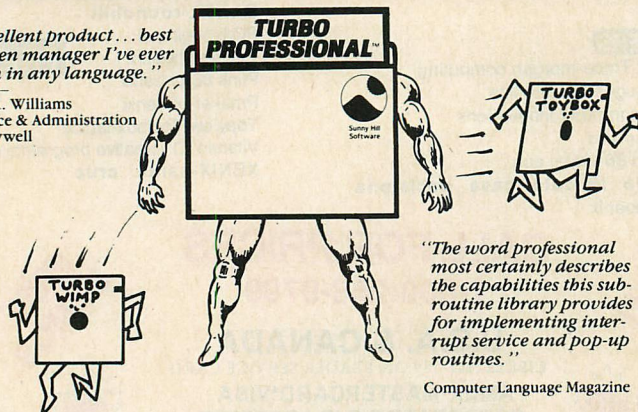
END-USER CONSIDERATIONS

It is difficult to imagine a Q-PRO4 application without menus. The program is

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unable to accept keyboard input except into screen data fields. The applications developer's approach to menus is not dictated by Q-PRO4. The sample application for this article was developed using function keys to select menu options, but numbers or letters could just as easily have been used, as is often done with other systems.

Q-PRO4 also offers a unique "moving X" menu selection technique.

Using this approach, a menu consists of a screen with entries such as

[] Author file maintenance

lined up in a column. An X appears inside the square brackets of one entry:

[X] Exit to the main menu.

By pressing the up or down arrow keys, the X is moved from entry to entry.

Pressing the return key indicates the

selection is complete. This technique is possible because of Q-PRO4's ability to have a programmed response to editing keystrokes, including the arrow keys. In this instance, all the fields can refer to the same procedure. The procedure's job is to determine which key was pressed, blank out the old selection, move to the field in the selection direction, then place an X in it. When the return key is pressed, the procedure

Q-PRO 4 OVERVIEW

Q-PRO 4, version 3.0

Q-N-E International, 136 Granite Hill Court, Langhorne, PA 19047; 215/968-5966

Product type. A database management and applications development system for general business use.

Software environment. CP/M-80, CP/M 3.0, CP/M-86, Concurrent CP/M, MP/M, MP/M-86, Concurrent DOS, MS-DOS, PC-DOS 1.x and 3.x, NSTAR, and TurboDOS.

Special environments supported. DESQ from Quarterdeck Office Systems.

Network support. PC Net, 3Com, Novell, and MultiLink.

Hardware environment. IBM PC, PC/XT, PC/AT, IBM compatibles, and multi-user systems with a minimum of 128KB of memory and two disk drives. Also supported are generic CP/M computers with 64KB of memory and two disk drives.

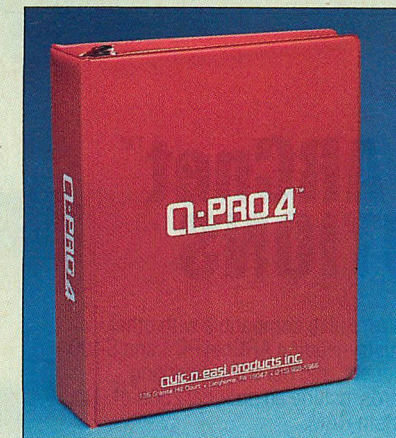
User interface. The program is menu-driven and uses macros/procedures and function/control keys. The command language, data definition, and data manipulation are English-like.

File limitations. 255 characters per field; unlimited characters per record; unlimited records per file; a maximum of 255 open files subject to operating system limits; 9 indexes per file. The basic architecture of the files is sequential, random, and indexed sequential.

Access to system facilities. From within the application the user is able to run any DOS program, including COMMAND.COM.

File modification facilities. The program can merge two or more files into a single file, as well as split a single file into two or more files. It can update a file with data from another file and can update multiple files simultaneously. The user can add fields without loss of data in a file.

Help facilities. On-line help for



queries and reports is provided. A written tutorial and a quick reference card also are included.

File design. The product uses a screen painting method of entry-screen design, allowing custom data-entry screens. The program supports derived fields using information from calculations, another file, or a user-supplied list or file of acceptable values. Other field attributes allow for view-only fields, numeric fields, user-defined numeric formats, and must-enter fields.

Data entry. The program automatically checks for duplicate entries in a file; range checking functions and batch data entry facilities are provided. The user can supply standard entry values during entry.

Query and sorting. Search facilities allow for partial key search, selection operators, and logical operators. Sorts may be performed in either ascending or descending order. The report program supports multiple sort operations on unlimited fields and multiple indexes on up to nine fields. Query and ordering specifications can be saved for repeated use, and the program provides automatic updating of indexes.

Reporting. Report formats can be

saved and edited, and individual reports can contain information from two or more files. The program produces label reports that can generate two-or-more-across labels. It also produces summary reports with a screen-painting design method that can include totals, subtotals, control breaks for pagination, and calculated results using four-function math, parenthetical control of order of operations, and averages. Final reports can include headings, footers, and pagination. Reports can be directed to the screen, a printer, or a disk file. Print enhancements available in the reports include bold and under-score. Paper size and margins can be specified in the report definition.

Security. The user can program password-protected access to fields.

Utilities. File maintenance, backup utilities, and print-outs of report and file-design definitions.

Applications development facilities.

Customization is possible with macros/procedures and custom menu generation. The program provides fully programmable procedural language and links to DOS applications or other languages. Turnkey applications can be generated.

Data compatibility. Utilities are provided to convert Lotus 1-2-3 and dBASE II files. The program reads and writes comma-delimited ASCII and fixed-length ASCII file formats.

Printers supported. The program supports all system-compatible printers.

Delivery. Began in October 1981; current version delivered in June 1984.

Distribution. Primarily through direct sales, distributors, and dealers.

Price. Retail: single-user version \$595; multiuser version, \$795.

Support. The product includes sample applications, telephone support, and a demonstration disk. Updates are available for a fee. Three backups are allowed for personal use.

determines which field was last used (a system register), then dispatches control to the appropriate routine.

Determining which keys perform which applications function is left entirely up to the developer. In fact, Q-PRO4 allows the developer to designate which PC keyboard keys will serve as keys 0 through 20. Within an application, the developer has the choice of whether the response to keys must be consistent from one function to another, or whether each format file can have its own menu. Function keys allow

the user to direct the course of the application through user events.

The Q-PRO4 application responds on a field-by-field basis (when appropriate), and text within fields can be edited with the left and right cursor keys and the insert and delete character keys. Keys also are defined to delete to the end of a field or an entire field.

Any number of help screens can be provided by the applications developer. Q-PRO4 can be programmed to have a single help key respond with help for the current field. A series of help

screens can be daisy-chained with a single Q-PRO4 statement, and the user can view only as much of the sequence as needed. When the data entry screen is restored following a help screen, the screen form and screen data fields are all intact, including the current cursor location. Therefore, help is not disruptive to the end user.

Field updates with Q-PRO4 are nearly instantaneous. Table look-ups, such as the state verification used in the sample application, also occur in a split-second. Moving between format files is a surprisingly fast operation. Q-PRO4 moves the form as a whole to screen memory and does not interleave composing the screen with its display, which partially accounts for the speed.

Integration with other programs, such as REPORT and Q-QUERY, is transparent to the user, because they can all be run from a Q-PRO4 application.

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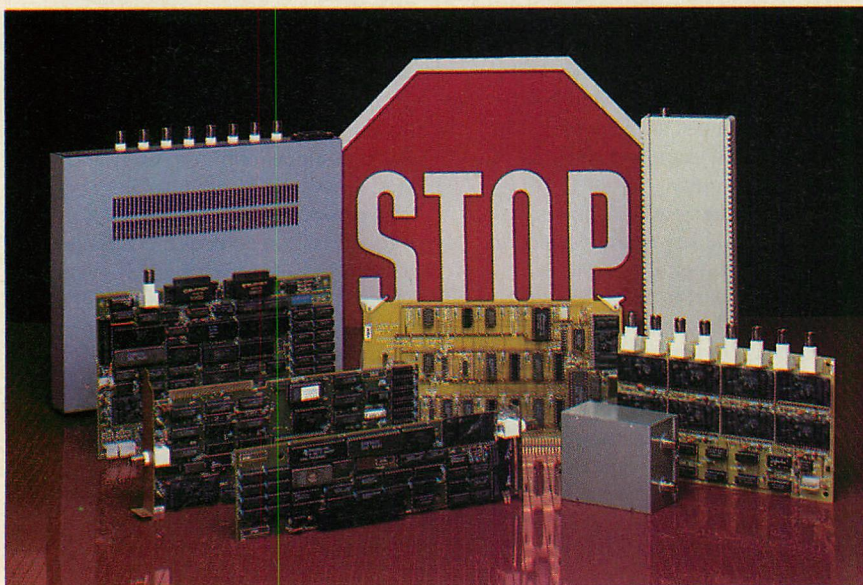
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THE SAMPLE APPLICATION

As with the other reviews in this series on database managers (see the August, September, October, November, and December issues of *PC Tech Journal*), Q-PRO4 was used to implement a simple editorial system designed by the *PC Tech Journal* editors. The sample application consists of three related files: an Article file containing the title, authors, page lengths, and other information about articles; an Author file with each author or coauthor's name, address, etc.; and an Issue file identifying each issue by volume and number and including the issue date and deadlines.

The Article file is related to both of the other files. An article's due date comes from the related Issue record via the article's volume and number. The Author file is related via both the author's and coauthor's names. This latter relation defines a requirement for up to two records of the Author file relating to a record of the Article file. This is a real-world problem that can make the application messy, depending on the strengths of the database manager.

Data for each file are provided in an ASCII comma-delimited format. Q-PRO4 provides no data loading facility, so an application was written in the Q-PRO4 language to perform the actual loads. First, each file was described with the file item descriptor program. The resulting FID files were used by the load application to create the Q-PRO4 data files. An interesting problem arose during the load itself. The files provided did not terminate with a Ctrl-Z to denote the end of file. Instead, the file length was available via DOS. Showing

its 8-bit heritage, Q-PRO4 attempted to read ASCII nulls at the end of the file. A simple edit with WordStar, which also treats DOS files as CP/M files, resolved the problem.

The file maintenance programs were written and tested. The Issue file, when read in key order, started with Volume 3 Number 1, then Volume 3 Number 10, then Volume 3 Number 2, etc. Q-PRO4 had stored the 1 and 2 data items literally as "1 " and "2 " (with a space inserted before the end quotes) in the data records, which made the file's index incorrect. A short investigation showed that the sequence

```
GET #S3 FROM 1
MOVE #S2 TO &number[2]
```

treated the file's field as a string although it was defined as numeric. Several different solutions were possible. The one chosen involved recoding that fragment of the program as

```
GET #S3 FROM 1
SIZE #S3 INTO #N1
IF #N1 = 1 CONCAT " " + #S3 INTO
&number[2]
IF #N1 = 2 MOVE #S3 TO &number[2]
```

QUERY subsequently was able to relate the Article and Issue files correctly, and file maintenance proceeded in the expected order of records.

Frustrations with the FB editor were mitigated with the crisp performance of the data entry screens as well as Q-PRO4's ability to chain between applications in a flash. Solving the problem mentioned above went quickly, because it involved only minor changes to established code. The close coupling between FB and QNE encourages experimentation with different approaches.

The shortcuts available through interrupt-style function key programs were appreciated, because the application could be tested for an end user one moment, then for an applications developer simply by selecting its method of use. With the end-user hat on, the test began at the main menu and passed through the menu network. Exiting the application was also through the main menu, and was complete with an "Are you sure?" question before returning to DOS. Switching to the applications developer's hat, the module under test was started up directly. TRACE and DEBUG were used, and either allowed to end normally, or, when necessary, the program was trapped out of directly to FB for editing or to DOS to restore a test data set.

Results of the performance benchmarks for Q-PRO4 are, for the most part,

a disappointment (see table 1). The benchmarks were designed to measure certain file operations. In four of the five benchmark tests, Q-PRO4 is the slowest of the six data managers tested so far in this series of reviews. In the fifth test it places in the middle of the pack.

All five of the benchmark tests involve accessing a single database via an index. Q-PRO4's compact binary index, instead of a balanced B-tree, is likely to blame for the poor performance. Q-NE has defined true B-tree indexes for an upcoming 16-bit release, so performance should improve.

The first benchmark involves loading a large database and creating its primary index. The second benchmark, which measures the creation of a new index for that database, shows no time for Q-PRO4 because it has no ad hoc index capability. Both Q-QUERY and REPORT can create temporary indexes, but Q-PRO4 proper cannot. Consequently, a new index is made by unloading the database and reloading it into a new file, redefining the original index in the process, then creating the new index. The third benchmark requires processing the data file in index order. Again, Q-PRO4's poor index performance causes it to take about twice as long as its nearest competitor in this series.

The fourth benchmark, which may be inconsistent between implementations, requires a change in a key field. B-tree index methods often postpone actual index reorganization until a file is closed, because a modest number of changes can be held in memory.

Q-PRO4's binary tree requires that the disk be updated to reflect the change in file keys. The benchmark actually has to delete the old record, then add the changed record to the file. The fifth benchmark involves using the new index created by the second benchmark as a method to perform a selective file unload. Q-PRO4 performs well, because it can do a partial key search to position the file for initial processing, then process the file in key order.

The last three benchmarks were written successfully with the Q-PRO4 report generator, including the file update. The Q-PRO4 language versions proved fast, because a procedural program can be tailored to a specific application—in these cases the manipulation of the file index for good performance. The orientation of the report generator is transaction summaries and master record updating. Its ability to define report fields via complex expressions and its notions of report region processing also work well and are not obscure.

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QPRO-4

Q-PRO4 documentation combines instructions for FB, QNE, RG, REPORT, and the supporting utilities in a single looseleaf binder. A self-teaching guide introduces the reader to FB, FID, and QNE and covers the construction of a simple application. Sample programs are included on disk. A programmer's reference makes up the second section of the manual.

A guide to the FID program comprises a separate section in the manual. The report generator and report program also have their own tutorial and reference sections. The detailed Q-PRO4 command reference presents the syntax of each command in alphabetical order and includes examples where appropriate. The appendix contains instructions for the utility programs, a list of reserved words, and a discussion of what to do when problems arise. The index covers each section and most material can be found fairly quickly. A programmer's reference guide groups Q-PRO4 statements by function. Documentation for the optional Q-QUERY program is separate, with its own tutorial, reference section, and index. It can be inserted into the main binder.

Minor inaccuracies are found throughout the documentation; many questions are best answered by trial and error. The sample programs are well worth studying for lessons in technique and use of most commands in an appropriate context.

Q-PRO4 offers a flexible and effective approach to data management through screen forms. Its crisp screen performance and user-event capabilities give sophisticated applications an inviting appearance to their users. At the same time, its applications development features allow development time to be focused on the application itself rather than the mechanics of the system.

Q-PRO4 encourages modular applications development. The capacities of the language are generous, and the inclusion of array structures is noteworthy. In the DOS environment, however, Q-PRO4's performance of data management functions compares poorly to its competitors. It is hampered by an index and data storage process better suited to memory-sparse 8-bit environments. Q-N-E International is revising the index method for future DOS releases. A solid user interface is now in place. With better file management methods Q-PRO4 may fulfill its potential for sparkling performance. 

Chris Christian is a software consultant specializing in dBASE applications.

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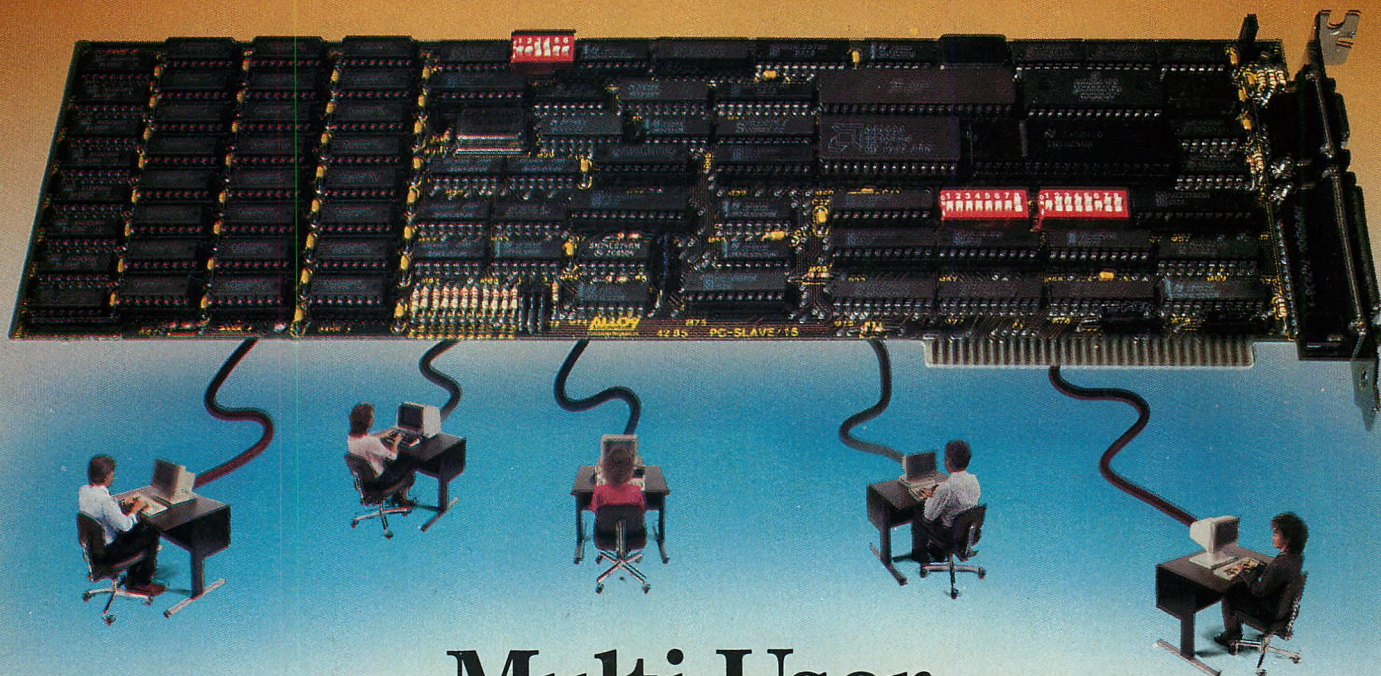
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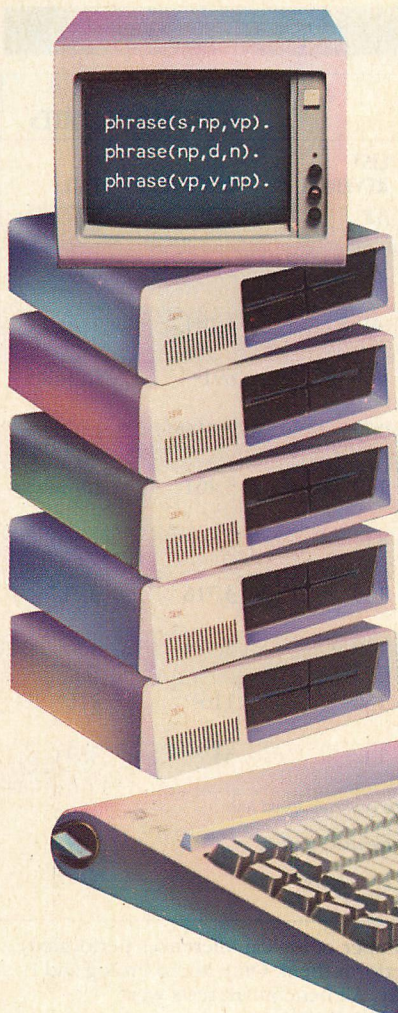
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Programming in Logic

The number of Prolog interpreters available to the user proliferates as the popularity of this programming language continues to increase; 11 implementations are reviewed here.

MICHAEL COVINGTON

Part 2

Implementations of the programming language called Prolog are proliferating at a rate comparable to that of word processors in 1983. Prolog is becoming increasingly popular because it provides support for a range of computer applications that could be handled only awkwardly, if at all, by conventional languages. Most programming languages are descended either directly or indirectly from FORTRAN. Arithmetic is the strong point of these languages, which are simply step-by-step recipes for performing calculations.

Prolog, by contrast, is neither numerical nor procedural. It is designed to reason. Prolog programs can diagnose diseases, identify animals, or figure out why a car will not start, (see "Programming in Logic, Part 1" Michael Covington, December 1985, p. 82). Furthermore, because a Prolog program is made up of a set of facts and rules rather than a description of a step-by-step process, Prolog is ideally suited for the next generation of parallel computers, machines that will perform more than one task at a time.

The distinction between compilers and interpreters is not as clear-cut in

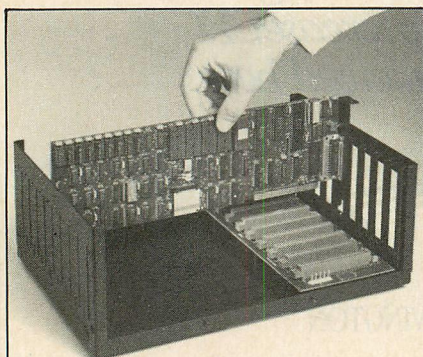
Prolog as in other programming languages. An interpreter reads statements and executes them immediately; a compiler translates the program into machine instructions. A Prolog program, however, does not execute in the ordinary sense. The rules and facts of which a Prolog program is composed form a data structure that the computer must search, not a series of step-by-step instructions that it must follow. As a result, compilers are unable to translate Prolog literally into machine language.

In addition, a Prolog program adds rules to itself while it is executing. These rules are, of course, written in Prolog, and the computer must be able to interpret them immediately. Therefore, any compiled Prolog program must have an interpreter built into it.

All but one of the 11 Prolog implementations reviewed here are interpreters; only the Arity/Prolog compiler produces self-standing .EXE files. A good interpreter is able to compile individual rules as they are read in. In other words, it stores them in a highly optimized internal form to minimize the work that must be performed each time the rules are applied.

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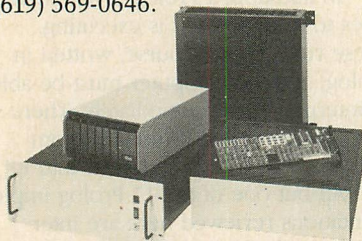
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PROGRAMMING IN LOGIC

TABLE 1: *Benchmarks*

	SPEED IN LIPS			RECURSION LIMITS	
	1-RULE DATABASE	101-RULE DATABASE	LIST REVERSAL	CENTER	TAIL
A.D.A. Public Domain 1.41	70 ^a	14.6	32	279	256
A.D.A. Educational 1.41	70 ^a	14.6	32	277	256
A.D.A. VML Prolog 1.51	13	10.5	40	1,104	1,003
Arity/Prolog Interpreter 3.2	149	8.9	86	891 ^b	Infinite
Arity/Prolog Compiler 3.2	1,435	189	989	2,716 ^b	Infinite
Micro-Prolog 3.1	221	26.5	142	3,461	Infinite
MPROLOG 1.5	123	12.8	84	2,500	2,500
Prolog-1 2.2 without editor	236	14.3	130	3,716	3,717
Prolog-1 2.2 with editor	227	Program too large	130	3,474	3,477
PROLOG-86 1.12	495 ^c	22.9	150 ^c	116 ^b	116 ^b
Prolog V 1.11	492 ^c	23.2	142 ^c	333 ^b	333 ^b

^a These results were obtained with a shorter version of the one-rule speed test; the full version would not run in available memory.
^b These limits depend on the amount of stack space that the user requests. The results shown were obtained with the default.
^c These programs would not run in the default amount of memory; the results shown were obtained by asking for more.

LIPS (logical inferences per second) is the number of logical inferences performed by a program divided by the time taken to perform them. Only Micro Prolog and Arity/Prolog implement tail recursion correctly. All benchmark tests were performed on an IBM PC using 640KB RAM and DOS 2.1.

ORIGINAL BENCHMARKS

Conventional benchmark programs, such as the Sieve of Eratosthenes, cannot be translated directly into Prolog and any attempt at a forced translation results in a program very unrepresentative of Prolog's normal applications. As a result, original benchmarks were developed to measure speed and memory usage (see table 1).

The speed of a Prolog implementation is measured in logical inferences per second (LIPS). One logical inference is the result of the computer's application of one rule. In a Prolog program such as

```
green(frogs).
colorful(X) :- green(X)
?- colorful(frogs).
```

the computer performs two logical inferences in order to conclude that `colorful(frogs)` is the logical deduction to be made from the rule set.

However, the computer does more than simply apply rules. It must search through the rule set to decide exactly which rules to apply. If, during this pro-

cess, Prolog uses a binary search, most of the rules actually are not examined at all. Consequently, if Prolog concludes that a certain rule is inapplicable, that step in the search should not be counted as a logical inference.

The only fair test is to measure the speed of a program comprised of one rule, then to compare that time to the time for a much larger program to determine how much the searching process slows Prolog down. Listings 1 and 2 show speed tests of programs comprised of 1 and 101 rules, respectively.

While both of these test programs involve a lot of arithmetic, most actual Prolog programs do very little numerical calculation. Thus, a completely non-numeric speed test program also is needed as a check. The list reversal program shown in listing 3, which is a Prolog translation of a classic LISP benchmark, provides this check.

Memory management is also important to test in a Prolog implementation. Prolog can express repetition either through recursion or backtracking, both of which involve placing infor-

TABLE 2: Prolog Implementation Features

	COPY PROTECTED	MEMORY REQ. (KB)	EDITOR INCLUDED	EDINBURGH SYNTAX	USER-ADJ. MEMORY	CALL NON-PROLOG	FLOATING-POINT	RANDOM FILE I/O	PATH NAMES	DOS SUBSHELL	SCR./CURS. CONTROL	PC COMPAT. REQ.
A.D.A. Public Domain 1.41	No	128	No	Yes	No	No	No	No	Yes	No	No	No
A.D.A. Educational 1.41	No	128	No	Yes	No	No	No	No	Yes	Yes	No	No
A.D.A. VML Prolog 1.51	No	256	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No
Arity/Prolog Interpreter 3.2	Yes	640	Yes	Yes	Yes	Yes	— ^a	Yes	Yes	Yes	Yes	Yes
Arity/Prolog Compiler 3.2	Yes	640	No	Yes	Yes	Yes	— ^a	Yes	Yes	Yes	Yes	Yes
Micro-Prolog 3.1	No	128	Yes	No	No	Yes	Yes	Yes	No	No	No	No
MPROLOG 1.5	Yes	512	Yes	Yes	Yes	No	No	No	No	No	No	Yes
Prolog-1 2.2	No	128	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No
PROLOG-86 1.12	No	128	No	Yes	Yes	No	No	No	No	No	No	No
Prolog V 1.11	No	128	Yes	Yes	Yes	No	No	No	No	No	No	No

^a Uses the 8087/287 if present.

Notice that the minimum memory required may not be sufficient to allow useful work to be done. Most vendors indicated that updates appear regularly. Users should call the local vendor to check on the current release.

mation on a pushdown stack. In some implementations the user can control the amount of memory set aside for the stack. If a Prolog interpreter skimps on stack space it cannot run programs that contain repetitive processes.

A test for the depth of recursion allowed by a Prolog implementation is shown in listing 4. The depth limit is the last number the program prints before it runs out of memory; the higher this number the better.

The program in listing 5 uses tail recursion, a process in which a rule invokes itself as the very last step. Because no steps remain for Prolog to execute after it returns from the recursive call, the procedure is carried out without any addition to the stack, and the depth limit should be infinite. Micro-Prolog and Arity/Prolog, however, are the only implementations tested in which this is actually the case.

PROLOG IMPLEMENTATIONS

At least 11 Prolog interpreters are available—in various stages of development. All of them have some rough edges, and their developers continue to release new versions and to add features. Table 2 summarizes the features of the products reviewed below.

A.D.A.: priced from \$0. Automata Design Associates (A.D.A.) produces many different levels of Prolog interpreters. The top-of-the-line implementation, called VML Prolog, is innovative and exceptionally full featured. The lowest level,

PD Prolog, is in the public domain; a copy is included with the purchase of Educational Prolog for \$29.95.

VML Prolog can refer to files by path name, peek and poke memory locations, and start a Prolog program from the command line. Its floating-point arithmetic package includes transcendental functions. In addition, any DOS command or program can be executed from within VML Prolog (a feature called a DOS *subshell*).

VML has a virtual memory feature; thus, the rules in a program need not reside in memory. Prolog maintains a table to keep track of where they are, then reads them in from this table when they are needed. This process is automatic, and as many rules as possible are stored in memory at the start. They are discarded if the space is needed for something else.

This process is augmented by a system of *domains* (modules) with IMPORT and EXPORT statements similar to those of Modula-2. The domains help solve the vexing problem of modularity in Prolog. With them, users can write programs in sections that do not interact in unexpected ways.

The greatest drawback of VML Prolog is its lack of speed. At 13 LIPS for the 1-rule speed test, it is the slowest of all the Prolog interpreters tested, and ran only one-twentieth as fast as Prolog-1. The extensive recursion in the speed tests requires a great deal of garbage collection, or memory reorganiza-

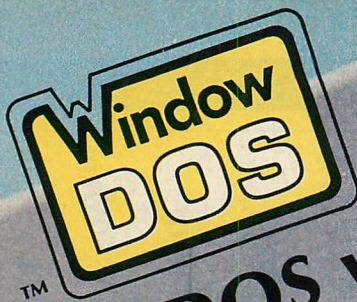
tion, which takes a lot of time. In the 101-rule speed test, which involves much less recursion than the others, VML Prolog is only slightly slower than its competitors. Neither virtual memory nor any of the built-in predicates that control the use of the stack was used when running these tests.

The VML Prolog manual contains a quite readable introduction to Prolog. However, it is not organized for quick reference. No index is provided, and some information, such as the overall memory requirements, does not seem to be provided anywhere.

VML Prolog is rough-hewn in other ways, also. The opening messages displayed by the test copy were not centered accurately on the screen. While this review was in progress, VML Prolog went through three or four revisions, from version 1.31 to 1.51.

The educational and public domain versions use a small model of memory and cannot utilize more than 256KB. They implement the full language described by W. F. Clocksin and C. S. Mellish in *Programming in Prolog* (Springer-Verlag, 1984), but the floating-point arithmetic and random file capabilities are missing. The educational version does include the DOS subshell, and the documentation distributed with the public domain version includes the same Prolog tutorial that is provided with the higher versions.

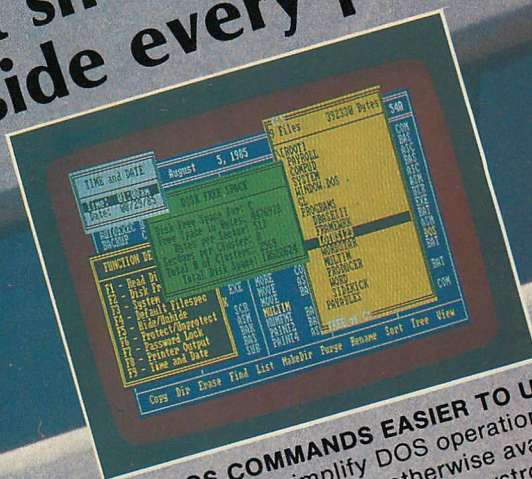
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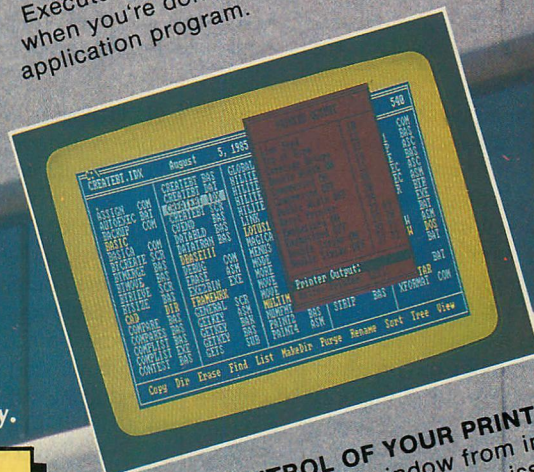
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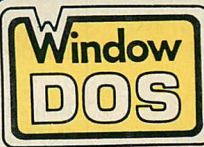
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Change default subdirectory	Yes	No	Yes	Yes	Yes	Yes
Create new subdirectories	Yes	No	Yes	Yes	Yes	No
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Display file in HEX format	Yes	No	No	Yes	No	Yes
Check or set time and date	Yes	No	Yes	No	Yes	Yes
Send printer control codes	Yes	No	No	No	No	No
Select default printer	Yes	No	No	No	No	No
Password "lock" computer	Yes	No	No	No	No	No
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interpreter and a compiler that generates self-standing .EXE files. The interpreter is available by itself for \$495. Release 3.2 of the compiler is protected by a Prolog key-disk system, but Arity has announced that the key-disk protection will be replaced with an install-deinstall copy-protection system in release 4.0. The Arity/Prolog interpreter is not copy protected.

Arity/Prolog is the most full featured of the implementations tested. It includes a full range of built-in predicates for screen control, windowing, string handling, and even a DOS sub-shell. Its floating-point arithmetic package automatically uses the 8087 coprocessor chip if one is present. Prolog programs can be linked to code written in assembly language or compiled with the Lattice C compiler, and the interpreter can be extended to include additional built-in predicates compiled by the Arity/Prolog compiler.

Although a brochure states that the Arity/Prolog interpreter requires only 256KB, it could not be loaded for testing on a 256KB machine. On a PC with 640KB, it performed well. The `consult` predicate (to load predicate definitions from a text file) executed rapidly, and Arity/Prolog lacked the garbage-collection pauses before every prompt so noticeable with other interpreters.

Performance on the tail recursion test was impressive; the test was stopped after 45,000 iterations. Like Micro-Prolog, described below, Arity/Prolog recognizes tail recursion as a special case and executes it without pushing an entry onto the stack each time.

Results on the center recursion test and the 1-rule speed test were average; Arity/Prolog was the slowest interpreter tested on the 101-rule speed test. The standard environment file (APIENV) was used for these tests, and no attempt was made to adjust the amount of memory allocated to various functions. The environment file allows considerable flexibility in configuring Arity/Prolog to match an individual application; however, it also may have acted as a handicap to the interpreter during the testing. The machine on which Arity/Prolog was tested may not have been used to its full potential; the documentation provided little guidance in this area.

The compiler accepts only Arity/Prolog programs that contain two special predicates: `main`, invoked automatically when the program starts running, and `restart`, invoked with Ctrl-Break. When these predicates, as well as the requisite declarations, are added to Arity/Prolog programs, they can be com-

plied to produce .OBJ files, then linked with ARITY.LIB using DOS LINK. Listing 6 shows the list reversal benchmark modified to be compiled and timed with the Arity/Prolog compiler. Each .EXE file thus created requires a matching .ENV (environment) file, created with Arity's ENVEDIT program, and an *atom closet* file, which is specified in the .ENV file. The default settings for all ENVEDIT parameters and the standard atom closet, INI.ATM, were used during testing for this review.

The Arity/Prolog documentation was a problem from the beginning. This was a result of bad planning and bad writing as well as the fact that the documentation and the product did not evolve together. For example, when the manual was written, the floating-point drivers were not implemented as separate driver files to be loaded at runtime. Other important differences between the documentation and the product also were evident during testing, which created a difficult learning curve. Much time was lost trying to resolve differences between the documentation, the copious README files, and the actual workings of the product.

Documentation is critical for Arity/Prolog because the compilation process is not traditional. It requires an input and an output atom closet; these can be the same file or two separate files. The atom closet file to be used with a given stand-alone program must be named correctly in the environment file. In addition, because the atom closet is changed during compilation, an old version cannot be used during execution of a compiled program or program action becomes unpredictable. The .EXE file, the atom closet file, the floating point driver files, and the environment file must all be in the same directory or any one of several (not always helpful) error messages appears.

Requiring so many separate files for a single stand-alone Prolog program seems unnecessary. Arity should provide a `make` utility (as is provided with most versions of UNIX) to manage the development of compiled programs. This is especially important given the interlocking dependencies of source, atom closet, and environment files in the Arity/Prolog implementation. Arity says such a program is under development and should be ready in 1986.

Despite these problems with documentation, the compiler proved to be a formidable performer. Compiles of short programs were completed in only a few seconds. The performance of the compiled code, as seen in table 2, sur-

passes all other interpreters tested by a considerable margin. The list reversal benchmark ran so quickly that it could not be timed via stopwatch, as all the others had been timed. It was rewritten to iterate the reversal process some number of times, and the effective duration of each iteration was calculated within the program. The modified list reversal benchmark is shown in listing 6. This listing also shows the special predicates required to compile correctly. All code correctly compiled also can be interpreted by Arity/Prolog. The compiler overhead is ignored by the interpreter and does not affect interpretation in any way.

Micro-Prolog: odd but good. The oldest of the microcomputer Prologs is Micro-Prolog, developed by Logic Programming Associates in England in 1980 and distributed in this country by Programming Logic Systems. Because it was developed originally for use with slow, small CP/M systems, it is very efficient, particularly in managing memory. Like Arity/Prolog, and unlike all the others reviewed here, it implements tail recursion without using the stack.

The version tested was 3.1, but version 4.0 should be available by the time this review is published. Programming Logic Systems promises major changes.

Micro-Prolog does not use the standard Clocksin and Mellish (Edinburgh) syntax. Instead, it uses a list notation based on LISP. For example, the rule `red(X) :- reddish(X), not(pale(X)).`

is written in Micro-Prolog as:

```
((RED X) (REDDISH X) (NOT PALE X))
```

No distinction is made between terms and lists; the term `a(b,c)` and the list `[a,b,c]` are both written `(A B C)`.

The strong tradition behind the Edinburgh syntax did not exist when Micro-Prolog was designed, so Micro-Prolog's syntax is more similar to that used in Prolog implementations integrated with LISP, especially on MIT-style LISP machines. It is easy to read after the user becomes accustomed to it. However, Micro-Prolog does not support meaningful names for variables; the only variable names possible are `X`, `Y`, `Z`, `X1`, `Y1`, `Z1`, and so forth. Micro-Prolog even renames variables to put them in canonical sequence.

Micro-Prolog is an editing environment. It assumes programs will be built a clause at a time, then saved as a whole. The user can alter clauses by re-typing them completely or by using the clause editor to change their internal structure. Loading of the clause editor

and various other utilities is optional; when memory is needed they can be left out. Any text editor can be used to edit Micro-Prolog programs.

Micro-Prolog was designed for the development of practical applications programs, not for experimentation. The user interface can be modified by changes to the top-level clause (analogous to LISP's READ-EVAL-PRINT loop) and by adding a new error handler. Queries included in a program are executed as soon as they are encountered during loading, and commands can be

passed to Micro-Prolog from the command line. Thus, a line such as

PROLOG LOAD MYPROG

can be included in a batch file. When the file is executed, the computer loads Micro-Prolog, which, in turn, loads MYPROG.LOG. This program can contain not only the clause definitions, but also a suitable query to start the action. The only other interpreter with a similar feature is A.D.A. VML Prolog.

Two translator programs are provided with Micro-Prolog, one of which,

DEC, simulates Clocksin and Mellish's original implementation on a DEC-10. It allows the use of Edinburgh syntax, but runs at only one-tenth the speed of pure Micro-Prolog and is of little use except as a teaching aid.

The other translator, SIMPLE, is designed for beginners; it allows clauses to be written in an English-like syntax. For instance, instead of

((LIKES JOHN MARY))

the user could write:

john likes mary

SIMPLE also contains various logical relations (such as *either* . . . *or*, and *for all*) as well as editing aids.

In spite of its name, SIMPLE seems to complicate the syntax of Micro-Prolog and tends to conceal its inner workings; the user can no longer tell at a glance what will pattern-match with what. In addition, SIMPLE takes up memory that could be put to better use.

The Micro-Prolog manual is well-written, thorough, and organized. The software also comes with a textbook called *Micro-Prolog: Programming in Logic*, by K. L. Clark and F. G. McCabe (Prentice-Hall, 1984), which deals lucidly with some important issues. However, this book uses SIMPLE almost exclusively; pure Micro-Prolog is not introduced until near the end.

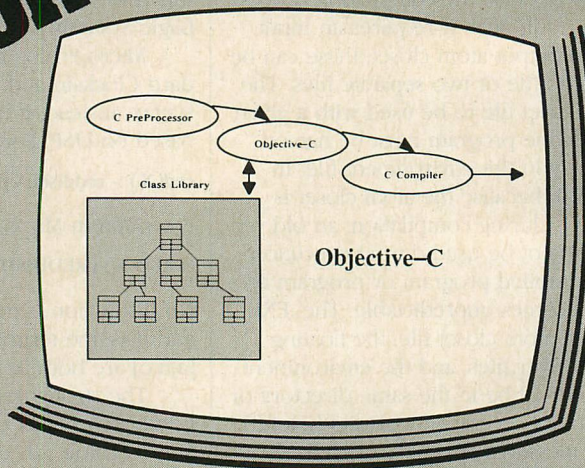
The manufacturer also offers an expert system building package called APES, which is outside the scope of this review. APES appears to be full-featured; it is written in Micro-Prolog (in module form so the user cannot list its clause definitions) and makes all the features of Micro-Prolog accessible to the expert system builder.

MProlog: mainframe compatibility. In many ways, Logicware's MProlog is the most sophisticated Prolog implementation tested. The PC version is an adaptation of a full-featured implementation for mainframe and minicomputers (the IBM 370, DEC VAX, Symbolics 3600, and others). Its documentation, a 500-page book in a 3-ring binder, carefully organized and neatly printed, is outstanding.

MProlog includes an extensive development system, although programs also can be edited with any text editor. The language implemented is a large superset of Clocksin and Mellish Prolog, and allows the user to break a program into modules and to control the internal workings of the interpreter. Curiously, floating-point arithmetic and random file I/O are not supported.

MProlog is quite demanding of machine resources; even with 640KB of

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memory, it has less stack space available for recursion than Prolog-1 or Micro-Prolog running with 128KB. MProlog loads from a floppy disk in about 1½ minutes. After it has been loaded, pauses are noticeable in the computer's response time to commands.

This product is copy protected; not even a backup copy may be made of the distribution disk. If MProlog is installed on a hard disk, the floppy disk is automatically modified so it no longer works. One backup disk is provided, and the vendor will replace a damaged copy of the protected disk for a small charge. However, the user should be hesitant about committing serious development projects to an interpreter tied to an individual key diskette.

Many features of the mainframe versions of MProlog are not available in PC version 1.5, although they are to be added in later versions. PC version 1.5 does not support modularity; nor does it include the pretranslation feature, which is the mainframe version's equivalent of compilation.

More importantly, MProlog does not contain any PC- or DOS-specific features, such as screen control or the use of tree-structured directories. No provisions have been made for such features to be included in later versions. This limits the usefulness of MProlog for production programming on the PC. MProlog is, however, a useful tool for developing programs that are to be ported to mainframes.

Prolog-1: fast and straightforward. One of the best all-around Prolog interpreters is Prolog-1 from Expert Systems International. It is available not only for DOS, but also for CP/M-86, CP/M-80, RT-11, RSX-11M+ (on the PDP-11), and VAX/VMS. The manufacturer has announced a compiler, Prolog-2, that not only runs 10 times faster, but also adds such features as virtual memory, windowing, and a full-screen editor.

Prolog-1 is a straightforward, well-documented implementation of the Clocksin and Mellish language, with an enhanced file handling system that supports the use of random-access files. The Prolog-1 reference manual is a well-organized summary of the entire language. Although Clocksin and Mellish's textbook is necessary to learn Prolog in general, the reference manual provides the user with quick answers to specific questions.

Prolog-1 includes an editor that builds a program from within the Prolog environment so the user can run parts of the program as it develops. This capability is more useful for learn-

ing the language than for production programming because it restricts the amount of available memory.

The editor is elegantly designed but has one obvious trap. The command *g* (for get) loads an entire file into the workspace. Logically, the user might assume that *s* (save) would save the entire workspace onto a file, but this is not the case. The command *s* saves only the *currently considered predicate* (the one the user was last working on). As a result, when *s* is used to save onto a file that was loaded with

g, all predicates except one are lost. Typed as an uppercase letter, the command *S* saves the entire workspace.

The demonstration programs provided with Prolog-1 include an expert system shell based on classificatory trees, a database with its own query language, a parser generator, and a symbolic differentiation program. These examples are important because they show how to construct a moderately large Prolog program, which Clocksin and Mellish do not do. In particular, the user can turn the expert system shell

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Benchmark results for runs of Prolog-1 on a machine with 128KB of memory were virtually identical to those obtained from test runs on a machine with 640KB.

Although its main file is named PROLOG86.COM, Prolog-1 is different from Solution Systems' PROLOG-86, which is discussed below.

PROLOG-86: language and examples. PROLOG-86 from Solution Systems runs with 128KB and is a minimum version of Edinburgh Prolog. Few new features have been added, and some standard ones are missing, such as the operator `=` that tests for equality without instantiating variables. By default, PROLOG-86 finds all solutions to a query, which may cause programs written in standard Prolog to give surprising results. Comments cannot be delimited by `/* */`, but must begin with `%` and continue to the end of the line.

The example programs supplied with PROLOG-86 are particularly interesting. They include the classic Towers of Hanoi game, a LISP-like set of routines for list and set manipulation, a program that performs symbolic differentiation of mathematical expressions, an action-planning program for a robot,

and four natural language processing programs. One of the language processing programs translates English sentences into predicate logic; another translates English questions into the DISPLAY commands used by dBASE II. The manual explains how the natural language programs work.

Prolog V might be called the Volkswagen Beetle of the Prolog world. It implements the language as described by Clocksin and Mellish with very few enhancements.

The tests for this review were performed with PROLOG-86 version 1.12; a new version subsequently has been released, which, according to the manufacturer, includes an editor, on-line help, and the ability to execute DOS commands from within Prolog.

Prolog V: teach yourself. In many ways, Prolog V from Chalcedony Enterprises

looks like PROLOG-86's twin brother. The two run at the same speed; both use a file called PROLOG.LIB to store predefined predicates, and both use a distinctive syntax in which the question mark can be written at the end of the query instead of at the beginning.

Prolog V is fast. At nearly 500 LIPS, it tied with PROLOG-86 for the best time in the 1-rule speed test. It lost its edge, however, in tests that required it to search a rule set.

Like Micro-Prolog, Prolog V easily creates programs within the Prolog environment; commands for loading, saving, and listing the workspace are provided, and the first chapter of the manual explains how to use them. Of course, it is equally practical to write the program on a text file with any editor, then load it using the **consult** command. Extensive facilities are provided for tracing and debugging.

Prolog V is fully functional on a 128KB machine. An added feature in version 1.11 allows the user to ask for extra stack space; this was a necessary step in order to run the 1-rule speed test and the list-reversal benchmark. The user can create predefined predicates by coding them in Prolog and adding them to the file PROLOG.LIB; these predicates will then be loaded every time the interpreter is invoked.

No problems with bugs or documentation errors were encountered during testing. *Computer Language* magazine recently reported that tracing is obligatory in Prolog V. This was certainly not found to be the case, either with version 1.10 or version 1.11.

One of Prolog V's best features is that the manual can serve as a tutorial for beginners. This, together with its low price, makes Prolog V excellent for educational use. In fact, the manufacturer offers special prices for on-site licenses for colleges.

Prolog V might be called the Volkswagen Beetle of the Prolog world. It implements the language as described by Clocksin and Mellish, but makes very few additions. However, the manufacturer has announced another interpreter, Prolog V Plus, which will include full-screen control, graphics, floating-point arithmetic, linkage to external programs, and the ability to use up to 640KB of RAM. At \$99.95, this will still be one of the least expensive Prolog interpreters available on the market.

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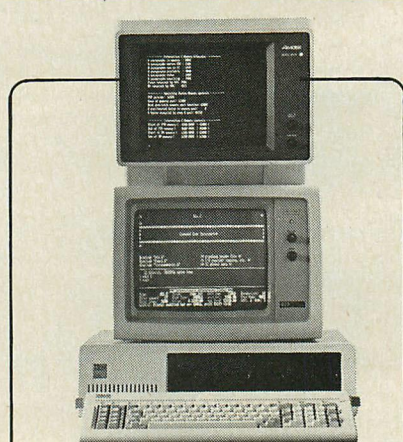
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and correct problems. The best all-around interpreter is probably Prolog-1, which is offered with the warning that it contains a pitfall here and there and suffers from shortages of memory when used with its own editor.

Only Arity/Prolog offers a compiler. Its price is steep, but the enhancement of performance over interpretive systems may make the package well worth the additional cost. The Arity compiler is a remarkable product, marred only, although seriously, by confused and incomplete documentation. The price of

release 4.0 of the Arity compiler/interpreter package will be falling sharply, from \$1,950 to \$795. If the documentation problem is corrected, and the copy protection removed, Arity/Prolog could become a truly excellent Prolog development tool.

Certainly Arity has the right idea. A development environment should contain both an interpreter for interactive development and debugging and a compiler for producing a stand-alone product that can be used effectively without the interpreter.

The more expensive Prologs are not necessarily the better Prologs. Programmers can successfully learn to work in this language with one of the less expensive interpreters. 

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LISTING 1: SPEED1.PRO

```
/* Speed test with a one-rule rule base */
test(X) :- Y is X-1,
           Y > 0,
           test(Y).
?- nl,nl,write('Starting...'),test(1000).
```

LISTING 2: SPEED 101.PRO

```
/* Speed test with a 101-rule rule base */
f(1).
f(2).
f(3).
f(4).
. /* The program as actually tested */
. /* contained all 100 rules of this form. */
. /* To run this program, fill in the */
. /* intervening rules in the form "f(x)". */
f(97).
f(98).
f(99).
f(100).

test(X) :- Y is X-1, f(X), test(Y).
?- write('Start...'), test(100).
```

LISTING 3: LISTREV.PRO

```
/* List reversal benchmark */
/* Number of logical inferences = (N**2 + N)/2 + N + 1, */
/* where N is the number of elements in the list. */

reverse([], []).
reverse([X|Y],Z) :- reverse(Y,Y1), append(Y1,[X],Z).
append([],X,X).
append([X|Y],Z,[X|W]) :- append(Y,Z,W).

/* To perform the test, generate a 30-element list */
/* and then reverse it (446 logical inferences). */

generate(0, []).
generate(N, [N|Y]) :- M is N-1, generate(M,Y).

test :- generate(30,X),
        write('Start...'),
        nl,
        reverse(X,Y),
        write(Y),
        nl,
        nl.
```

LISTING 4: RECURSE1.PRO

```
/* Normal recursion test */
f(X) :- write(X), nl, Y is X+1, f(Y), write(Y), nl.
?- f(1).
```

LISTING 5: RECURSE2.PRO

```
/* Tail-recursion test */
f(X) :- write(X), nl, Y is X+1, f(Y).
?- f(1).
```

LISTING 6: TIMEREV.PRO

```
/* List reversal benchmark */
/* Modified for use with Arity/Prolog Compiler */

:- public main/0.
main :-
    write('Number of iterations: '),
    read(N),
    generate(30, X),
    time(Start),
    fiftytests(X, N),
    time(Aftertest),
    fiftyplaceboes(X, N),
    time(End),
    tdiff(Start, Aftertest, Testinterval),
    tdiff(Aftertest, End, Controlinterval),
```

```
Testtime is (Testinterval - Controlinterval) / N,
write(Testtime).
```

```
/* Number of logical inferences = (N**2 + N)/2 + N + 1, */
/* where N is the number of elements in the list. */
```

```
reverse([], []).
reverse([X|Y],Z) :- reverse(Y,Y1), append(Y1,[X],Z).
append([],X,X).
append([X|Y],Z,[X|W]) :- append(Y,Z,W).
```

```
/* To perform the test, generate a 30-element list */
/* and then reverse it (446 logical inferences). */
```

```
generate(0, []).
generate(N, [N|Y]) :- M is N-1, generate(M,Y).
```

```
fiftytests(X, N) :-
    for(1, N, _),
    reverse(X, Y),
    fail.
```

```
fiftytests(_, _).
```

```
fiftyplaceboes(X, N) :-
    for(1, N, _),
    placebo(X, Y),
    fail.
```

```
fiftyplaceboes(_, _).
```

```
placebo(_, _).
```

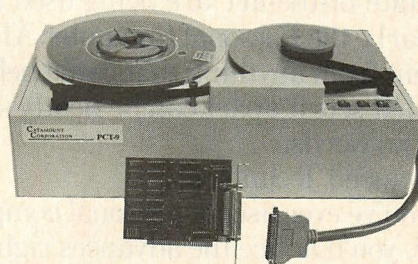
```
tdif(time(H1,M1,S1,Hn1), time(H2,M2,S2,Hn2), A) :-
    A is (H2 - H1) * 3600 +
        (M2 - M1) * 60 +
        (S2 - S1) +
        (Hn2 - Hn1) / float(100).
```

```
for(1, I, I) :- !.
```

```
for(1, J, I).
```

```
for(1, J, K) :- inc(I, I1), for(I1, J, K).
```

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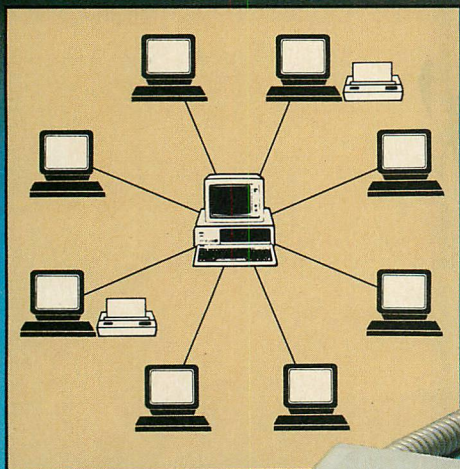
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Curves Made Simple

With its versatile graphics support, the PC now lends itself easily to the graphing of data formerly trusted to minicomputers and mainframes.

FRANK G. LETHER

Many data reduction tasks that were formerly limited to mini and mainframe computers can now be performed on the PC. The graphics support offered by the PC makes it possible to plot interesting and detailed curves on the screen. The quality of the graphs produced by PC graphics support is frequently adequate for the initial technical purposes of mathematics, science, and engineering. If a reproduction quality graph is needed, the data can be uploaded from the PC to a minicomputer and a commercial graphics package used to create and draw an india ink plot on the minicomputer's high-resolution pen plotter.

This article offers a BASIC program that permits the user to plot data without having to become involved with the technical aspects of the PC's graphics commands. The program takes a list of (x,y) data points contained in a specified, sequential data file and outputs a completed graph. The program assumes that the x -axis is horizontal and the y -axis is vertical. In order to avoid positioning problems, the plotting program

puts numeric labels only at the endpoints of each axis. Interior tic marks with numeric labels are not provided.

The (x,y) data points are connected by line segments on the screen. If the data set has enough points, the resulting graph will appear unbroken when displayed on the PC's 640-by-200 pixel graphics screen. Program options allow the user to draw a solid annotation square around each data point, draw the graph with or without axes and labels, specify a title for the graph, and select uniform or nonuniform axis scaling. The size of the annotation square can be adjusted in order to achieve interesting visual effects.

GRAPH-2D in listing 1 is the actual plotting program. It can be run with the BASIC interpreter or compiled with the IBM BASIC Compiler for increased performance. GRAPH-2D does not use the WINDOW, VIEW, or TIMER commands, nor the style option of the LINE command. Although these commands are supported by the interpreter in BASICA under DOS 2.0, they are not supported by the IBM BASIC Compiler. Addition-

ally, since GRAPH-2D contains an ON ERROR with a RESUME line construction, the /E compiler parameter must be specified to assure correct compilation.

Two generic programs, GENDATA and KEYDATA (listings 2 and 3, respectively), can be used to create some sample (x,y) data files for testing purposes. GENDATA generates four sequential data files from various mathematical functions. KEYDATA accepts data points from the keyboard as input and then writes them to a specified data file. Both of these programs are designed to be used with the BASIC interpreter. (In fact, GENDATA cannot be compiled as written due to multiple definitions of the functions F and G.)

To test GRAPH-2D, first run the data generation program GENDATA. The four sequential data files created by this program, EX#1.DAT, EX#2.DAT, EX#3.DAT, and EX#4.DAT, contain many more points than would be practical to enter by hand. This test data can be graphed with GRAPH-2D.

A user also can choose to create his own data files by entering the data

from the keyboard. Run KEYDATA and follow the prompts: a maximum of 10 (x,y) data points can be keyed in. The numbers x and y must be separated by a comma before the carriage return is pressed. Otherwise, a "Redo from start" message will be returned, since no user input checks are used in KEYDATA.

To graph one of these test data files, just run GRAPH-2D and respond to the prompts; the following two screen prompts will always be returned:

```
Enter data filename
Graph data using defaults ? Enter y or n
```

With regard to the first prompt, the file name extension .DAT will be supplied by the program if another has not been specified. For example, to name the first data file created by GENDATA, the user could simply enter EX#1 (the program will add .DAT). If the file is named (with an extension other than .DAT) both the name and the extension will have to be entered in response to the first prompt.

If the user elects to use the defaults in the second prompt by responding y or Y , the program will automatically construct a graph of the data with the following defaults: no title, axes drawn with no horizontal or vertical axis names, nonuniform scaling, and annotation squares of size one drawn around the data points (more on the annotation size later).

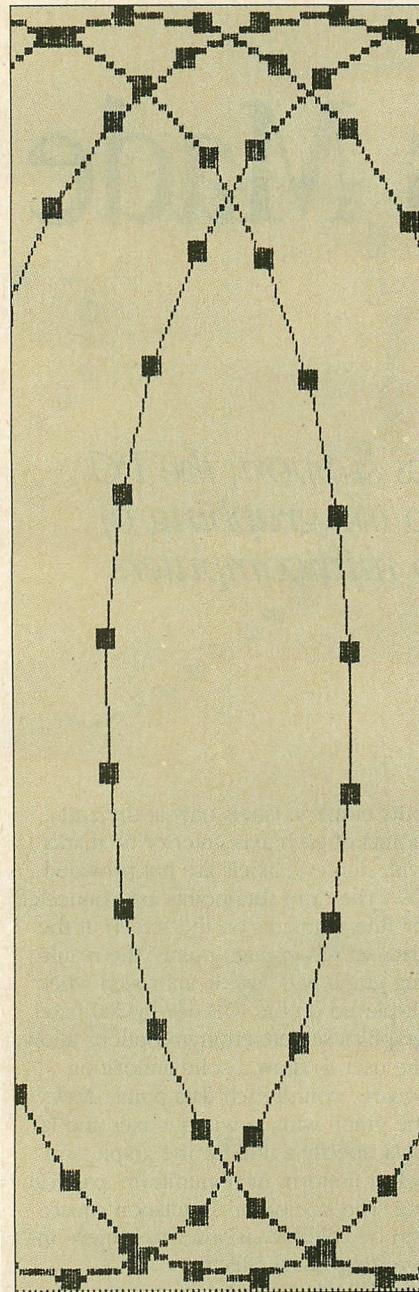
The graph will be displayed on the screen until either e or E is pressed to erase the screen. A short reminder message to this effect will momentarily be displayed to the right of the graph. The Shift-PrtSc key, as supported by DOS 2.0's GRAPHICS command, will print the screen graph on a compatible dot-matrix printer. Custom graphs are created by using settings other than those offered by default. A response of n or N to the second prompt will produce the following additional prompts:

```
Enter title of graph
Enter horizontal axis name
Enter vertical axis name
Draw axes ? Enter y or n
Use uniform scale ? Enter y or n
Annotate points ? Enter y or n
Enter annotation size
```

The user may enter any title or axis name he wishes or simply press the Enter key without typing in anything for a null entry. Generally it is not desirable to use uniform scaling in order to cause the graph to fill the allotted plot region on the screen. Uniform scaling uses the same scale on both the x and y axes and would be useful, for example, in

plotting inclined lines to avoid a distortion of the line's true slope.

If the user elects to annotate the data points with a solid square, he must specify the annotation size in the last prompt. This size should be a positive integer greater than or equal to 1. It will help in understanding the size parameter to draw a couple of graphs



using different annotation sizes. (The default in this case is size 1 squares.)

As written, GRAPH-2D can handle a maximum of 500 data points. This restriction can be changed by replacing 500 in lines 80 and 85 with another value. The default settings employed by GRAPH-2D are initialized in lines 400-405. The plot subroutine documentation in lines 1140-1200 will help in under-

standing how to redefine the defaults to suit individual needs.

In cases in which GRAPH-2D will always be run using the BASIC interpreter, the frame around the graph will be drawn slightly faster if lines 1830-1900 are deleted and lines 1910-1920 are "uncommented." This invokes the style option on the LINE command that is not supported by the IBM BASIC Compiler. A user may also choose to remove the one-second and one-half-second delays introduced in lines 340-345 and line 575. These delays are necessary to reading the information displayed on the bottom of the screen when the faster compiled version is being run on smaller data files.

DATA FORMAT

Both GENDATA and KEYDATA write each (x,y) data point to a sequential data file with the x coordinate in the first column and the y coordinate in the second column. The columns are separated by blanks, with the numbers x and y being expressed in scientific notation. GRAPH-2D reads this type of data file and connects consecutive points in order, starting at the top of the file.

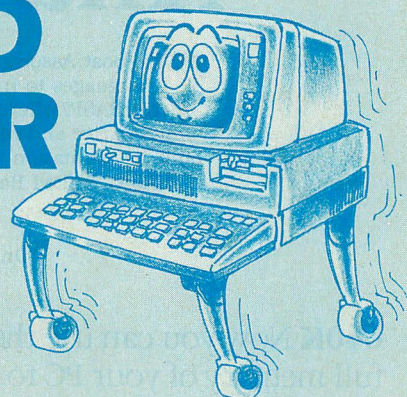
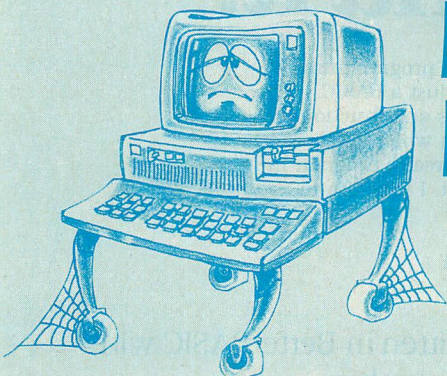
Using this type of data file is advantageous because it can be uploaded to a mini or mainframe computer and directly processed with existing FORTRAN software on the larger target machine. For example, after doing preliminary graphics work on the IBM PC using GRAPH-2D, the user may decide to upload selected data to a Digital Equipment Corp. PDP 11/70 minicomputer. Commercial FORTRAN can be used on the PDP to generate a publication-quality graph on a high-resolution California Computer Products pen plotter.

It is easy to use GRAPH-2D to graph many of the equations commonly encountered in mathematical developments. To this end, several points must be plotted on the plane curve defined by the given equation. These points can be obtained using a simple BASIC program, such as GENDATA.

This stand-alone program generates N data points on a curve defined by parametric equations of the form $x = g(t)$ and $y = f(t)$. The (x,y) data points are then computed and written to a sequential data file through the action of lines 490-540 and 560-570.

Generating data on curves through their parametric equations is a particularly useful technique on a computer: a much larger variety of curves can be defined parametrically than is possible with such common curve representations as $y = f(x)$.

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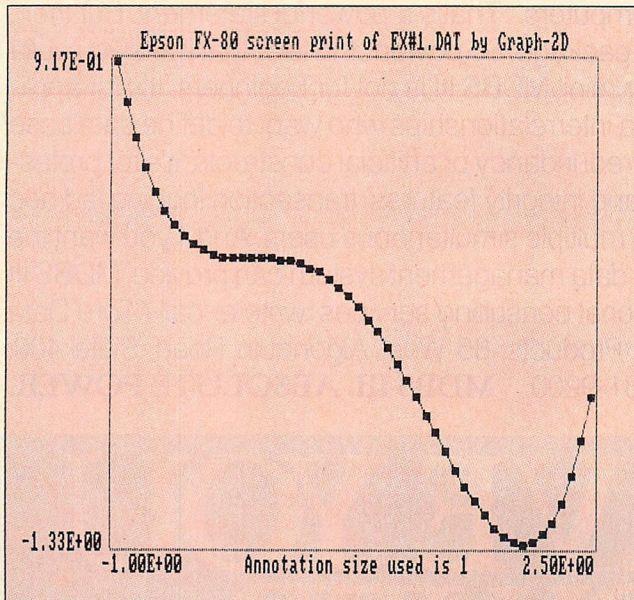
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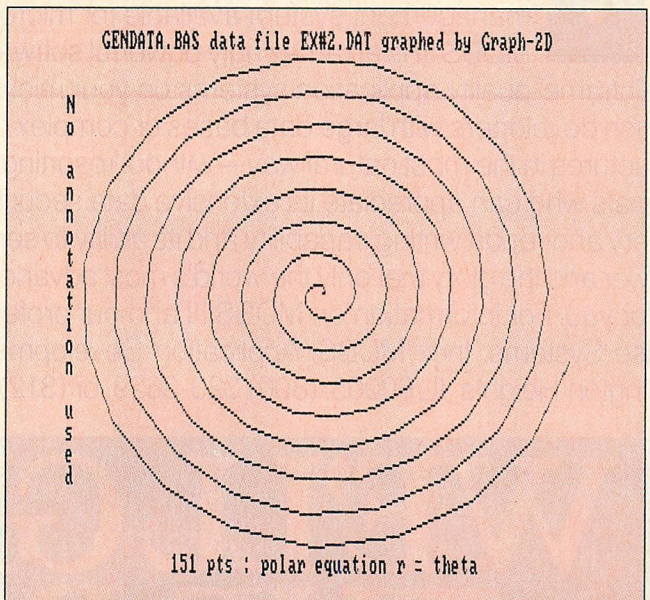
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FIGURE 1: A Polynomial Curve

This polynomial curve shows the graph generated from the data file EX#1.DAT built by GENDATA.BAS.

FIGURE 2: A Spiral Curve

This spiral curve, generated from EX#2.DAT (lines 220-260 in GENDATA.BAS), uses no annotation points.

Common equations of the form $y = f(x)$ can be written in parametric form simply by taking $g(t) = t$. It is worth noting that the familiar polar equation $r = b(\theta)$ can be expressed in the above parametric form by taking

$$\begin{aligned} g(t) &= b(t) \cos(t) \\ f(t) &= b(t) \sin(t) \end{aligned}$$

These latter equations are derived from the familiar polar to Cartesian coordinate conversion equations given by $x =$

$r \cos(\theta)$ and $y = r \sin(\theta)$. Here, the parameter t is the angle θ .

GENDATA illustrates these ideas. The fourth degree polynomial

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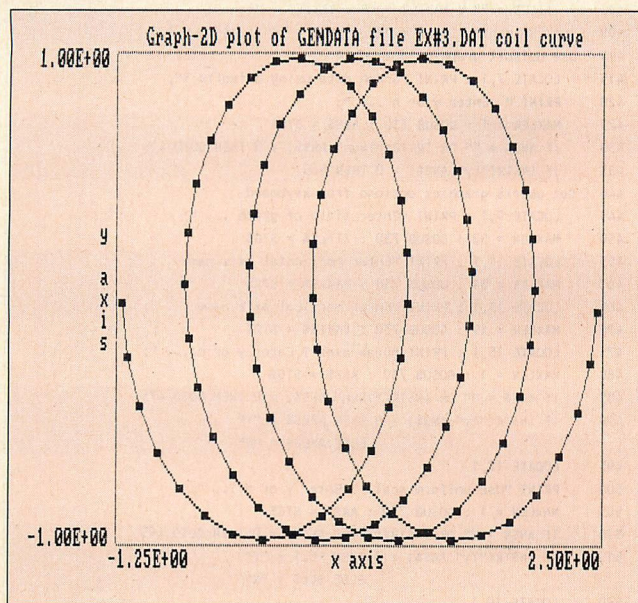
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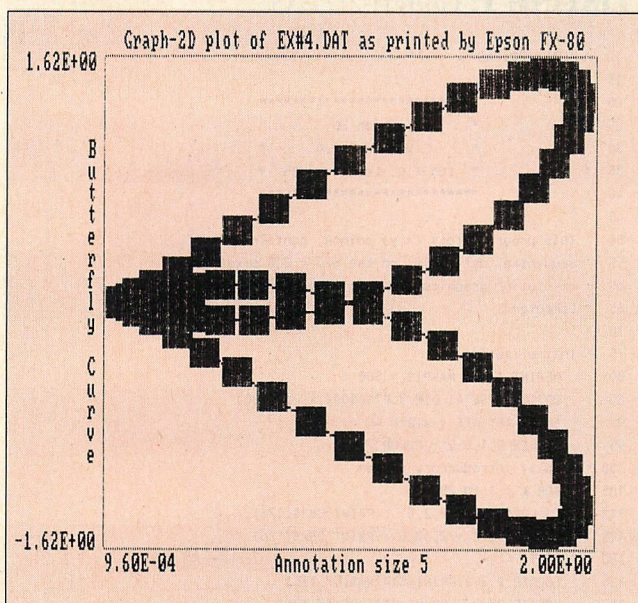
Not long ago, *PC Magazine* called MDBS III "The most complete and flexible data base management system available for microcomputers." That's a powerful statement. But then, MDBS III is an amazingly powerful software package. So powerful, in fact, that it lets you build mainframe-quality application systems on your micro or mini. MDBS III is not for beginners. It's for application developers with large data bases or complex data interrelationships who want to define data base structures in the most natural way—without resorting to redundancy or artificial constructs. It's for professionals who can appreciate its extensive data security and integrity features, transaction logging, ad hoc query and report writing capability and its ability to serve multiple simultaneous users. And if you want the power and the glory that only the world's most advanced data management system can provide, MDBS III is for you. For information on MDBS III and our professional consulting services, write or call Micro Data Base Systems, Inc., MDBS/Application Development Products, 85 West Algonquin Road, Suite 400, Arlington Heights, IL 60005. (800) 323-3629, or (312) 981-9200. **MDBS III. ABSOLUTE POWER.**

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FIGURE 3: A Coil Curve

The points in the data file EX#3.DAT (from lines 280-320 in GENDATA.BAS) produced this coil curve.

FIGURE 4: A Butterfly Curve

The butterfly curve plotted from EX#4.DAT (from lines 340-380), uses size five annotation points.

is defined by the parametric equations in lines 160-170 (figure 1). The spiral defined by the polar equation $r = \theta$ is expressed in lines 220-230 (figure 2).

The graphing of more exotic parametric curves, such as those for a coil

curve (figure 3) and for a butterfly curve (figure 4) specified in lines 280-290 and 340-350, respectively, of GENDATA.BAS, are discussed in J. Dennis Lawrence's *Catalog of Special Plane Curves* (Dover, 1972). This inexpensive

paperback book has computer-drawn graphs for many curves, along with their equations.

Frank G. Lether, Ph.D., is a professor of mathematics at the University of Georgia.

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(1) *Computer Language*, Feb., 1985, pp.73-102. Reprinted by permission.

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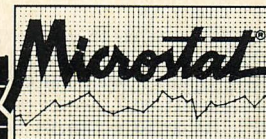
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Trademarks: Eco-C88, Microstat (Ecosoft), CP/M (Digital Research), MSDOS (Microsoft), PC-DOS (IBM), Z80 (Zilog), 8086, 8087, 8088 (Intel).

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LISTING 1: GRAPH-2D.BAS

```

10 ' GRAPH-2D.BAS
15 '
20 ' *****
25 ' *          Graph-2D          *
30 ' *          Version 1.0        *
35 ' * (c) F.G. Lether 1985      *
40 ' *****
45 '
50 ' This program plots (x,y) points, contained in a
55 ' sequential data file, on the 640 x 200 pixel high
60 ' resolution graphics screen of the IBM Personal
65 ' Computer.
70 '
75 ' Initialization
80   DEFINT I-N : MAXPTS = 500
85   OPTION BASE 1: DIM X.PTS(500),Y.PTS(500)
90   CLS : KEY OFF : WIDTH 40
95   SCREEN 0,1,0,0 : COLOR 7,0,0
100 ' Display introductory screen
105   FOR K = 1 TO 20
110     LOCATE K + 2,2,0 : PRINT CHR$(176);
115     LOCATE K + 2,38,0 : PRINT CHR$(176)
120   NEXT
125   LOCATE 2,2 : PRINT STRING$(37,176)
130   LOCATE 23,2 : PRINT STRING$(37,176)
135   FOR K = 1 TO 6
140     LOCATE K + 5,10,0 : PRINT CHR$(176);
145     LOCATE K + 5,30,0 : PRINT CHR$(176)
150   NEXT
155   LOCATE 5,10 : PRINT STRING$(21,176)
160   LOCATE 11,10 : PRINT STRING$(21,176)
165   COLOR 15
170   LOCATE 7,17 : PRINT "Graph-2D"
175   LOCATE 9,15 : PRINT "Version 1.0"
180   LOCATE 15,7 : PRINT "Copyright 1985 F.G. Lether"
185   COLOR 0,7
190   LOCATE 19,9 : PRINT " Press Esc key to quit "
195   LOCATE 21,6 : PRINT " Press space bar to continue "
200   COLOR 7,0
205 ' End if Esc key or continue if space bar pressed
210   IF INKEY$ <> "" THEN 210
215   KEYCHR$ = INKEY$ : IF KEYCHR$ = "" THEN 215
220   IF KEYCHR$ = CHR$(27) THEN CLS : WIDTH 80 : END
225   IF KEYCHR$ <> CHR$(32) THEN 215
230 ' Display user input screen
235   CLS : WIDTH 80
240   LOCATE 1,37 : PRINT "Graph-2D"
245   LOCATE 2,37 : PRINT STRING$(8,196)
250 ' Get user data filename and read data
255   LOCATE 5,1,0
260   PRINT "Enter data filename ... ";
265   MAXLEN = 52 : GOSUB 730 : F$ = STG$
270   IF LEFT$(F$,1) = " " OR F$ = "" THEN : GOTO 255
275   IF INSTR(F$,".") = 0 THEN F$ = F$ + ".DAT"
280   ON ERROR GOTO 595
285   OPEN F$ FOR INPUT AS #1
290   LOCATE 25,23
295   PRINT "Please wait, reading input data ...";
300   N.PTS = 0
305   WHILE NOT EOF(1)
310     N.PTS = N.PTS + 1
315     IF N.PTS > MAXPTS THEN 335
320     INPUT #1,X.PTS(N.PTS),Y.PTS(N.PTS)
325     LOCATE 25,60 : PRINT N.PTS;" points";
330   WEND
335   CLOSE #1
340   SCND = 1! : TICS = 18.2 * SCND : SILENT = 32767
345   SOUND SILENT,TICS : SOUND SILENT,1
350   LOCATE 25,23 : PRINT STRING$(49,32);
355   IF 2 <= N.PTS AND N.PTS < MAXPTS THEN 390
360     LOCATE 7,1 : SOUND 40,1
365     PRINT "Number of points in data file ";
370     PRINT "out of range !"
375     IF N.PTS > MAXPTS THEN PRINT " Too many points"
380     IF N.PTS < 2 THEN PRINT " Less than 2 points"
385   END
390   ON ERROR GOTO 0
395 ' Set default graphics options

```

```

400   TITLE$ = "" : XAXIS$ = "" : YAXIS$ = ""
405   AXES$ = "Y" : SCL$ = "N" : ANNS$ = "Y" : JSIZE = 1
410 ' Use default graphics options ?
415   LOCATE 7,1 : PRINT "Graph data using defaults ?";
420   PRINT " Enter y or n ... ";
425   MAXLEN = 1 : GOSUB 730 : ANNS$ = STG$
430   IF ANNS$ = "" OR INSTR("Ynyn",ANNS$) = 0 THEN GOTO 415
435   IF INSTR("Yy",ANNS$) > 0 THEN 565
440 ' Get user's graphics options from keyboard
445   LOCATE 9,1 : PRINT "Enter title of graph ... ";
450   MAXLEN = 52 : GOSUB 730 : TITLE$ = STG$
455   LOCATE 11,1 : PRINT "Enter horizontal axis name ... ";
460   MAXLEN = 34 : GOSUB 730 : XAXIS$ = STG$
465   LOCATE 13,1 : PRINT "Enter vertical axis name ... ";
470   MAXLEN = 19 : GOSUB 730 : YAXIS$ = STG$
475   LOCATE 15,1 : PRINT "Draw axes ? Enter y or n ... ";
480   MAXLEN = 1 : GOSUB 730 : ANNS$ = STG$
485   IF ANNS$ = "" OR INSTR("Ynyn",ANNS$) = 0 THEN GOTO 475
490   IF INSTR("Yy",ANNS$) > 0 THEN AXES$ = "Y"
      ELSE AXES$ = "N"
495   LOCATE 17,1
500   PRINT "Use uniform scale ? Enter y or n ... ";
505   MAXLEN = 1 : GOSUB 730 : ANNS$ = STG$
510   IF ANNS$ = "" OR INSTR("Ynyn",ANNS$) = 0 THEN GOTO 495
515   IF INSTR("Yy",ANNS$) > 0 THEN SCL$ = "Y"
      ELSE SCL$ = "N"
520   LOCATE 19,1
525   PRINT "Annotate points ? Enter y or n ... ";
530   MAXLEN = 1 : GOSUB 730 : ANNS$ = STG$
535   IF ANNS$ = "" OR INSTR("Ynyn",ANNS$) = 0 THEN GOTO 520
540   IF INSTR("Yy",ANNS$) > 0 THEN ANNS$ = "Y"
      ELSE ANNS$ = "N"
545   IF ANNS$ = "N" THEN 565
550   LOCATE 21,1 : PRINT "Enter annotation size ... ";
555   MAXLEN = 2 : GOSUB 730 : JSIZE = VAL(STG$)
560   IF JSIZE < 1 THEN JSIZE = 1
565   LOCATE 25,24
570   PRINT "Please wait, determining graph ...";
575   SOUND SILENT,.5*TICS : SOUND SILENT,1
580   GOSUB 1330 ' plot data data
585   GOTO 90
590 ' Error trapping for input data file
595   SOUND 40,1 : LOCATE 7,1
600   PRINT "Can't obtain input data ";
605   PRINT "using this filename !"
610   IF ERR = 71 THEN PRINT " Disk not ready ."
615   IF ERR = 53 THEN PRINT " Data file not found ."
620   IF ERR = 64 OR ERR = 76 THEN
      PRINT " Bad data filename ."
625   PRINT : COLOR 0,7
630   PRINT " Press space bar to retry ";
635   PRINT "or press Esc key to stop "
640   COLOR 7,0 : RESUME 210
645   ON ERROR GOTO 0
650   END
655 ' -----
660 ' SUBROUTINE - get keyboard input
665 ' -----
670 ' This subroutine restricts user keyboard input to a
675 ' horizontal box of specified length, the box starting
680 ' at the current position of the cursor. (The code is a
685 ' modified version of some techniques suggested by
690 ' G. Cuellar for controlling user input .)
695 '
700 ' Input to this subroutine
705 ' MAXLEN length of input box (# characters allowed)
710 '
715 ' Output from this subroutine
720 ' STG$ characters entered in the box from keyboard
725 '
730   LOCATE ,,0 : SOUND 40,1
735   BOX$ = CHR$(29) + CHR$(176) + CHR$(29)
740   STG$ = ""
745   DEF FN BCK$(STG$) = LEFT$(STG$,LEN(STG$)-1)
750   PRINT STRING$(MAXLEN,CHR$(176));
755   FOR K = 1 TO MAXLEN
760     PRINT CHR$(29);
765   NEXT

```

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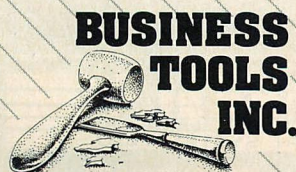
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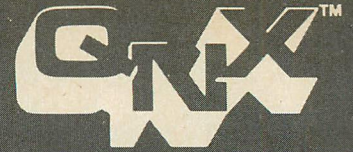
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Technical Bulletin

No. 2 in a series.



SUBJECT: Engineering a LAN for Maximum Flexibility.

Quantum Software Systems Ltd. proudly announces QNX 2.0 — the Ultimate Distributed Network Operating System. QNX 2.0 is now available for the IBM-PC, IBM-AT, PC compatibles, DEC Rainbow and TANDY 2000. If you have been waiting for a Real-time Multi-tasking Multi-user Operating system with fourth generation LAN support, then QNX 2.0 can offer you today what the competition can't even begin to promise for the future.

QNX 2.0 integrates the Local Area Network architecture right into the heart of the operating system, at the fundamental level of intertask communication allowing tasks to communicate transparently with other tasks across the whole network. This means that any task (program/application) may access ANY serial port, ANY printer or ANY disk on the network. There are no artificial restrictions. Every PC with a disk is a potential file server. PCs without disks will automatically BOOT over the network.

QNX on the IBM-PC AT:

QNX is the first Multi-tasking Multi-user Operating system available for the AT. It is available in both networked and single machine configurations. At about 2.5 times faster than the QNX 8088 PC based systems, and 10 times faster than other multi-tasking operating systems on the same processor, QNX is the ideal program development environment.

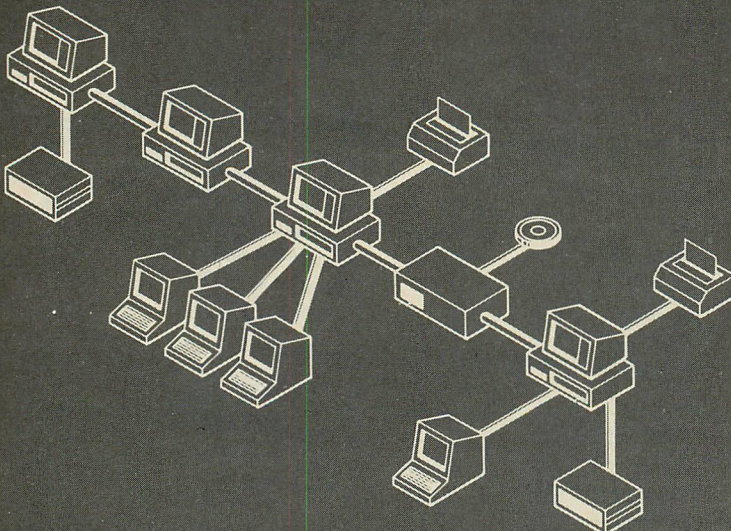
O/S	Computer	Processor	Measured time
QNX™	IBM-PC AT	80286	480 usec
XENIX™	Intel-286	80286	4,930 usec

File Security:

Designed with extensive file security features, QNX 2.0 provides login protection with network wide file permission checking based on 255 groups of 255 users. In addition, each PC user may control network access to devices attached locally to their machine.

Distributed Processing:

The QNX LAN supports distributed processing as well as distributed devices. Tasks may be executed on remote stations as easily as they may be executed on the local work station. This allows pure processing elements (PCs without keyboards or displays) to be plugged into the network to be used as an



un-committed processing resource. This is ideal for real-time, process control, data acquisition and data communication applications.

Global Communications:

QNX supports a full implementation of X.25 allowing connection to public networks such as Telenet and Datapac. This allows you to link geographically separate LANs together providing true global area networking.

Cost Effective Growth and Flexible Solutions:

QNX is affordable, and will work with the PCs you use today and those you will use tomorrow. You may mix and match different brand PCs on the same QNX network with absolute ease. Multi-user expansion may be accomplished by adding terminals to PCs or PCs to the network. You can start your multi-user application on a single PC with 1 to 10 attached terminals. Once your single processor starts to show signs of degradation, add another PC and connect terminals to the new processor. If the disk becomes the major bottleneck, you may add hard disks to other attached PCs to distribute the processing. Applications which are very CPU intensive may wish to limit a single user to each processor and expand the system with low cost diskless PCs used as work stations. QNX does offer a truly cost effective and flexible solution to your applications needs.

Portability:

QNX 2.0 is portable. The operating system is independent of the physical local area network. It is available in a form suitable for porting to other 8088/8086/80186/80286 computers in the consumer, educational and industrial market place. QNX is ROMable and can operate in as little as 128Kb RAM.

DOS Compatibility:

PC-DOS version 2.1 can run as a task under the QNX 1.2 or 2.0 operating systems. QNX will also allow transparent access to the DOS file system partition and floppies.

QNX Products:

QNX Operating System	PC-DOS Emulator
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Extended Utilities	Electronic Teleconferencing
C Compiler & 8086 Assembler	Full Screen Menu Developer
Basic Compiler	Isam File Utility
Qbol (dibol) Compiler	Networking Board
Text Processor	OEM Customization Kit
Real Time Spelling Checker	(to port QNX)

Established:

Quantum sold over 10,000 copies of its operating system during 1984, into all business systems environments, to developers of real time applications, government and educational systems, to software developers/integrators, universities and research establishments.



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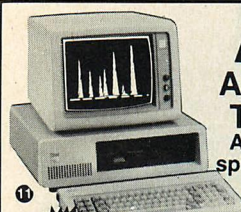
770 LOCATE ,,1,7,7 : KEYCHR$ = INPUT$(1)
775 IF KEYCHR$ = CHR$(8) THEN IF STG$ = "" THEN 770 ELSE
    STG$ = FN BCK$(STG$) : PRINT BOX$ : GOTO 770
780 IF KEYCHR$ = CHR$(13) THEN
    FOR K = 1 TO MAXLEN - LEN(STG$)
        : PRINT " " : NEXT : GOTO 795
785 IF KEYCHR$ < CHR$(32) OR KEYCHR$ > CHR$(126) THEN 770
790 IF LEN(STG$) = MAXLEN THEN 770 ELSE PRINT KEYCHR$ :
    STG$ = STG$ + KEYCHR$ : GOTO 770
795 LOCATE ,,0
800 RETURN
1000 '-----
1010 ' SUBROUTINE - plot data points
1020 '-----
1030 ' This subroutine plots (x,y) points on the 640 x 200
1040 ' pixel graphics screen of the IBM PC. It employs the
1050 ' 432 x 180 pixel, centered viewport (104,10)-(535,189).
1060 ' This subroutine requires a color graphics adapter
1070 ' card and BASICA.
1080 '
1090 ' Input arguments to this subroutine are as follows :
1100 ' MAXPTS the maximum number of (x,y) points allowed
1110 ' N.PTS actual number of (x,y)-points to be plotted
1120 ' X.PTS array of abscissa x-points to be plotted
1130 ' Y.PTS array of ordinate y-points to be plotted
1140 ' XAXIS$ label for horizontal x-axis (can be blank)
1150 ' YAXIS$ label for vertical y-axis (can be blank)
1160 ' TITLE$ title for graph (can be blank)
1170 ' AXES$ set to "Y" or "y" to plot axes
1180 ' SCL$ set to "Y" or "y" to use same axis scales
1190 ' ANN$ set to "Y" or "y" to annotate all points
1200 ' JSIZE size of annotation square, e.g. 1,2,3,...
1210 '
1220 ' Restrictions for this subroutine are as follows :
1230 ' MAXPTS should be >= 2, and less than maximum
1240 ' number of anticipated points ever to be plotted.
1250 ' Arrays X.PTS and Y.PTS should be dimensioned to
1260 ' MAXPTS in the calling code.
1270 ' N.PTS must satisfy 2 <= N.PTS <= MAXPTS
1280 ' The respective strings XAXIS$, YAXIS$ and TITLE$
1290 ' should not consist of more than 34, 19 and 52
1300 ' characters, respectively.
1310 '
1320 ' Compute minimum and maximum of x and y points
1330 DEF FN BIG(A,B) = B*ABS(A<B) + A*ABS(A>B)
1340 DEF FN SMALL(A,B) = B*ABS(A>B) + A*ABS(A<B)
1350 X.MIN = X.PTS(1) : X.MAX = X.PTS(1)
1360 Y.MIN = Y.PTS(1) : Y.MAX = Y.PTS(1)
1370 FOR K = 2 TO N.PTS
    X.MIN = FN SMALL(X.PTS(K),X.MIN)
    X.MAX = FN BIG(X.PTS(K),X.MAX)
    Y.MIN = FN SMALL(Y.PTS(K),Y.MIN)
    Y.MAX = FN BIG(Y.PTS(K),Y.MAX)
1420 NEXT
1430 ' Adjust maximums if uniform scaling
1440 IF SCL$ <> "Y" AND SCL$ <> "y" THEN 1470
1450 IF (X.MAX - X.MIN) > (Y.MAX - Y.MIN) THEN
    Y.MAX = Y.MIN + (X.MAX - X.MIN) ELSE
    X.MAX = X.MIN + (Y.MAX - Y.MIN)
1460 ' Set 432 X 180 pixel viewport (104,10)-(535,189)
1470 S.ASPECT = 51 / 121
1480 Y.PIXELS = 180
1490 X.PIXELS = CINT(Y.PIXELS / S.ASPECT)
1500 I.MIN = 104 : I.MAX = I.MIN + X.PIXELS - 1
1510 J.MIN = 10 : J.MAX = J.MIN + Y.PIXELS - 1
1520 ' If points annotated with squares, adjust viewport size
1530 IF ANN$ <> "Y" AND ANN$ <> "y" THEN 1590
1540 JSIZE = ABS(JSIZE) : JSIZE = FN BIG(JSIZE,1)
1550 ISIZE = CINT(11 + JSIZE / S.ASPECT)
1560 I.MIN = I.MIN + ISIZE : I.MAX = I.MAX - ISIZE
1570 J.MIN = J.MIN + JSIZE : J.MAX = J.MAX - JSIZE
1580 ' World to physical coordinates transformation
1590 J.RANGE = J.MAX - J.MIN : Y.RANGE = Y.MAX - Y.MIN
1600 I.RANGE = I.MAX - I.MIN : X.RANGE = X.MAX - X.MIN
1610 IF Y.MAX > Y.MIN THEN Y.SCALE = J.RANGE / Y.RANGE
1620 IF X.MAX > X.MIN THEN X.SCALE = I.RANGE / X.RANGE
1630 X.ADJ = I.MAX - X.SCALE * X.MAX
1640 Y.ADJ = J.MAX + Y.SCALE * Y.MIN
1650 ' Special case of horizontal or vertical line
1660 IF X.MAX = X.MIN THEN X.SCALE = 0! :

```

```

X.ADJ = .5 * (I.MAX + I.MIN) :
X.MIN = X.MIN - 1 : X.MAX = X.MAX + 1
1670 IF Y.MAX = Y.MIN THEN Y.SCALE = 0! :
Y.ADJ = .5 * (J.MAX + J.MIN) :
Y.MIN = Y.MIN - 1 : Y.MAX = Y.MAX + 1
1680 DEF FN I.MAP(X) = CINT(X.SCALE * X + X.ADJ)
1690 DEF FN J.MAP(Y) = CINT(Y.ADJ - Y.SCALE * Y)
1700 ' Plot x,y points on high res graphics screen
1710 SCREEN 2
1720 IX = FN I.MAP(X.PTS(1)) : JY = FN J.MAP(Y.PTS(1))
1730 PSET (IX,JY)
1740 IF ANN$ = "Y" OR ANN$ = "y" THEN
    LINE (IX-ISIZE,JY+JSIZE)-(IX+ISIZE,JY-JSIZE),,BF:
    PSET (IX,JY)
1750 FOR K = 2 TO N.PTS
1760 IX = FN I.MAP(X.PTS(K)) : JY = FN J.MAP(Y.PTS(K))
1770 LINE -(IX,JY)
1780 IF ANN$ = "Y" OR ANN$ = "y" THEN
    LINE (IX-ISIZE,JY+JSIZE)-(IX+ISIZE,JY-JSIZE),,BF
    : PSET (IX,JY)
1790 NEXT
1800 ' If points annotated, restore original viewport parms
1810 IF ANN$ = "Y" OR ANN$ = "y" THEN
    I.MIN = I.MIN - ISIZE : I.MAX = I.MAX + ISIZE :
    J.MIN = J.MIN - JSIZE : J.MAX = J.MAX + JSIZE
1820 ' Draw axes if requested and label axis max and mins
1830 IF AXES$ <> "Y" AND AXES$ <> "y" THEN 1980
1840 LINE (I.MIN-2,J.MIN-1)-(I.MIN-2,J.MAX+1)
1850 LINE (I.MAX+2,J.MIN-1)-(I.MAX+2,J.MAX+1)
1860 LINE (I.MIN-2,J.MIN-1)-(I.MAX+2,J.MIN-1)
1870 LINE (I.MIN-2,J.MAX+1)-(I.MAX+2,J.MAX+1)
1880 FOR K = I.MIN - 2 TO I.MAX + 2 STEP 2
1890 PRESET(K,J.MIN-1) : PRESET(K,J.MAX+1)
1900 NEXT
1910 " LINE (I.MIN-2,J.MIN-1)-(I.MAX+2,J.MIN-1),,,&HAAA
1920 " LINE (I.MIN-2,J.MAX+1)-(I.MAX+2,J.MAX+1),,,&HAAA
1930 LOCATE 2,4 : PRINT USING "###.##^####": Y.MAX ;
1940 LOCATE 24,4 : PRINT USING "###.##^####": Y.MIN ;
1950 LOCATE 25,13 : PRINT USING "###.##^####": X.MIN ;
1960 LOCATE 25,59 : PRINT USING "###.##^####": X.MAX ;

```

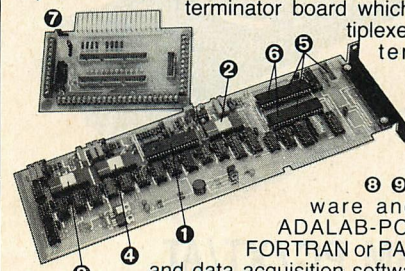


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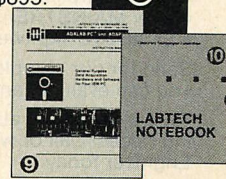


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```

1970 ' Write graph title (can be blank)
1980   TTLS = LEFT$(TTITLE$,52)
1990   LOCATE 1,(41 - LEN(TTLS) / 2) : PRINT TTLS
2000 ' Write x,y axis labels (can be blank)
2010   XAXS$ = LEFT$(XAXIS$,34)
2020   LOCATE 25,(41 - LEN(XAXS) / 2) : PRINT XAXS;
2030   YAXS$ = LEFT$(YAXIS$,19)
2040   FOR K = 1 TO LEN(YAXS)
2050     LOCATE (12 - LEN(YAXS) / 2) + K , 12
2060     PRINT MID$(YAXS,K,1);
2070   NEXT
2080 ' Display user prompt beside graph for only DELAY seconds
2090   DEF FN SECONDS = 3600 * VAL(LEFT$(TIME$,2))
        + 60 * VAL(MID$(TIME$,4,2))
        + VAL(RIGHT$(TIME$,2))
2100   DELAY = 1.5 : TIME0 = FN SECONDS
2110   LOCATE 2,69 : PRINT "*****";
2120   LOCATE 3,69 : PRINT "press key e";
2130   LOCATE 4,69 : PRINT "to erase the";
2140   LOCATE 5,69 : PRINT "screen ...";
2150   LOCATE 6,69 : PRINT "*****";
2160   IF (FN SECONDS - TIME0) < 3 THEN 2160
2170   FOR K = 0 TO 4
2180     LOCATE 2 + K,69 : PRINT SPACE$(12);
2190   NEXT
2200 ' Wait for E or e key press to return to calling program
2210   KEYSYMS$ = INKEY$
2220   IF KESYMS$ <> "E" AND KESYMS$ <> "e" THEN 2210 : CLS
2230   RETURN

```

LISTING 2: GENDATA.BAS

```

100 ' GENDATA.BAS
110 '
120 ' Generates 4 files of (x,y) test data from functions
130 '
140   CLS : WIDTH 80 : KEY OFF : DEFINT I-N
150 ' Example 1 : polynomial curve
160   DEF FN G(T) = T
170   DEF FN F(T) = (.25*T - .666667)*T^3
180   T.START = -1 : T.END = 2.5 : N = 50

```

```

190   FILES$ = "EX#1.DAT"
200   GOSUB 440
210 ' Example 2 : spiral curve
220   DEF FN G(T) = T*COS(T)
230   DEF FN F(T) = T*SIN(T)
240   T.START = 0 : T.END = 50 : N = 151
250   FILES$ = "EX#2.DAT"
260   GOSUB 440
270 ' Example 3 : coil curve
280   DEF FN G(T) = COS(4*T) + .32*T
290   DEF FN F(T) = SIN(4*T)
300   T.START = -.78 : T.END = 4.7 : N = 100
310   FILES$ = "EX#3.DAT"
320   GOSUB 440
330 ' Example 4 : butterfly curve
340   DEF FN G(T) = 1 + SIN(T)
350   DEF FN F(T) = (1 + SIN(T)) * COS(.5*T)
360   T.START = 0 : T.END = 12.57 : N = 75
370   FILES$ = "EX#4.DAT"
380   GOSUB 440
390 '
400   PRINT "Done ..." : PRINT
410   END
420 '
430 ' SUBROUTINE - generate and write an (x,y) data file
440   PRINT "Creating data file "; FILES$
450   PRINT STRING$(18,250) + " " + STRING$(LEN(FILES$),196)
460   PRINT "Number of points to be generated = "; N ;
470   LINECUR = CSRLIN
480   PRINT : PRINT
490   OPEN FILES$ FOR OUTPUT AS #1
500   DELTA = (T.END - T.START) / (N - 1) : T = T.START
510   FOR K = 1 TO N
520     X = FN G(T) : Y = FN F(T)
530     T = T + DELTA
540     PRINT #1,USING "#.#####^" "X;Y
550     LOCATE LINECUR,50 : PRINT K
560   NEXT
570   CLOSE #1
580   LOCATE LINECUR,50 : PRINT STRING$(5,32)
590   PRINT : PRINT
600   RETURN

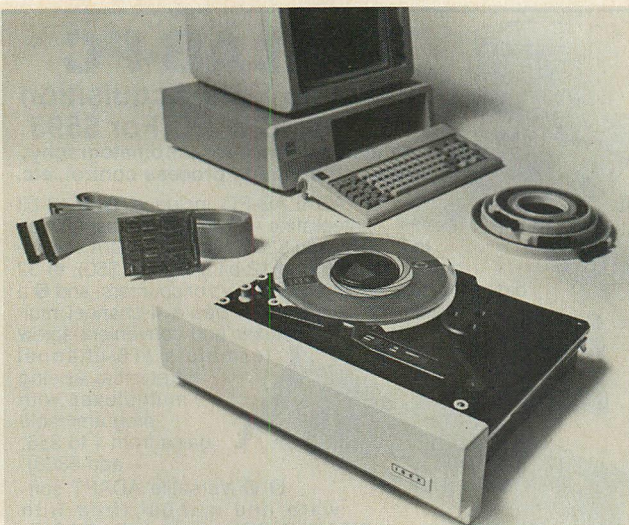
```

LISTING 3: KEYDATA.BAS

```

100 ' KEYDATA.BAS
110 '
120 ' Creates a file of (x,y) test data, entered from keyboard
130 '
140   CLS : WIDTH 80 : KEY OFF : DEFINT I-N
150   MOST.PTS = 10
160   OPTION BASE 1 : DIM X(MOST.PTS),Y(MOST.PTS)
170   INPUT "Enter desired output data filename ",FILES$
180   PRINT : PRINT "Opening output file " + FILES$
190   PRINT STRING$(19,45) + " " + STRING$(LEN(FILES$),196)
200   OPEN FILES$ FOR OUTPUT AS #1
210   PRINT
220   INPUT "Enter total number of data points ",N
230   IF N > MOST.PTS THEN 210
240   CLS
250   PRINT "Total number of points to be entered is ";N
260   PRINT
270   FOR I = 1 TO N
280     PRINT " point number ";I;
290     INPUT " ... enter x , y ",X(I),Y(I)
300   NEXT
310   CLS : PRINT "Summary" : PRINT
320   FOR I = 1 TO N
330     PRINT " ... point number ";I;
340     PRINT " is " "X(I);";";Y(I)
350   NEXT
360   PRINT : PRINT "Press the space bar to write ";
370   PRINT "data to file " + FILES$
380   IF INKEY$ <> "" THEN 380
390   KESYMS$ = INKEY$ : IF KESYMS$ = "" THEN 390
400   IF KESYMS$ <> CHR$(32) THEN 380
410   FOR I = 1 TO N
420     PRINT #1,USING "#.#####^" "X(I);Y(I)
430   NEXT
440   CLOSE #1
450   PRINT : PRINT "Done ..." : PRINT
460   END

```



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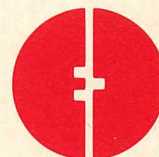
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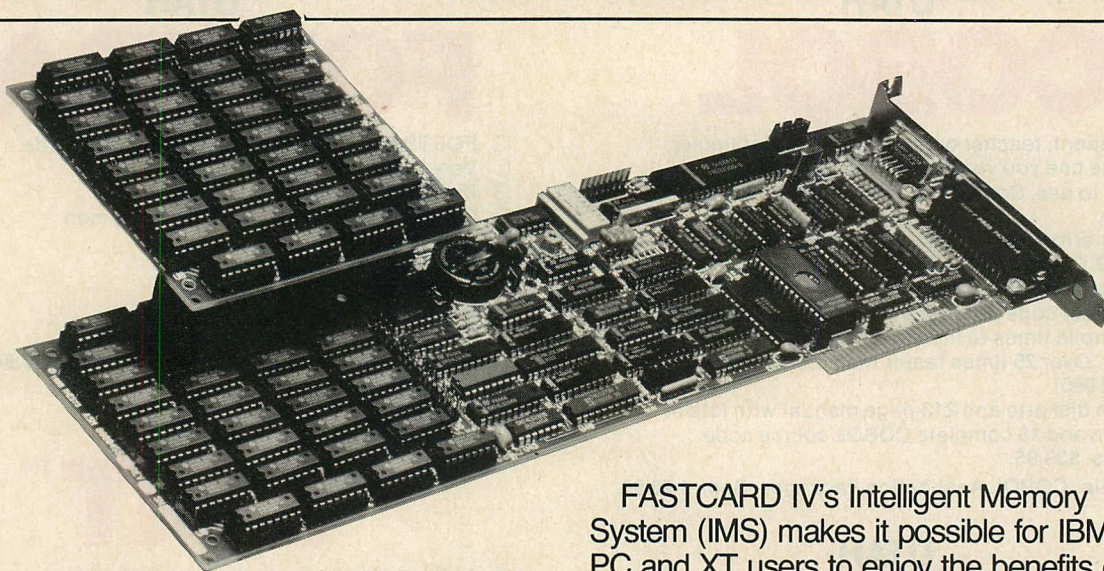
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Customized Scrolling

With these instructions a programmer can scroll the screen of his PC any number of lines up or down, to the right or to the left.

Images on the screen of the IBM PC can be scrolled only with software; no scrolling circuitry is included in the hardware (although an approximation of scrolling can be derived with the 6845 display controller chip.) The PC's inherent scrolling routines are contained in the ROM BIOS and are listed in the technical manual. This copyrighted software is not present in IBM-compatible systems, and every producer of an IBM-compatible machine has created its own scrolling software.

While these implementations of scrolling software allow the user to move any rectangular area on the screen any number of lines up or down, they make no provision for horizontal movement. This is unfortunate because the program for horizontal scrolling is similar to that for vertical scrolling, and horizontal scrolling is a valuable capability when working with many popular applications such as word processors, spreadsheets, or games.

In its simplest form, scrolling is accomplished with the registers of the 6845 display controller. A block of memory called a *display buffer* holds the data displayed on the screen. One register pair in the 6845 determines exactly where the first character of the display can be found within this buffer. Addresses are sent to fetch this first character and proceed to fetch additional characters in sequence until they reach the end of the display buffer, at which time they wrap around and return to the beginning. This type of scrolling can be accomplished by invoking BASIC and, for a monochrome adapter, typing:

```
10 OUT &H3B4,13
20 OUT &H3B5,80
30 ^C
RUN
```

This will scroll the screen up one line.

These statements should not be attempted in immediate mode because

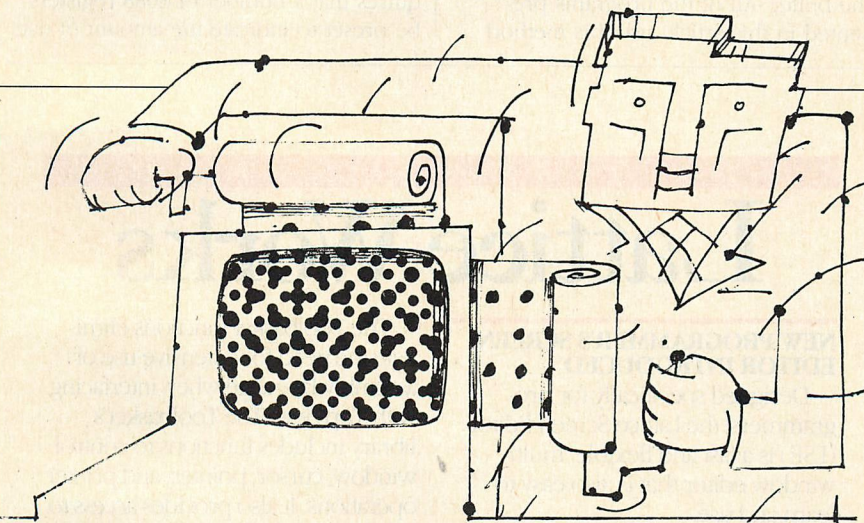


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immediate mode resets the controller after each line, thereby negating that line's effect. When in text mode, using either IBM's Color Graphics Adapter or Enhanced Graphics Adapter, lines 10 and 20 must be substituted with the lines OUT &H3D0,13 and OUT &H3D1,80, respectively. A POKE to offset 4000 in the correct display buffer will fill the bottom line with new text. As an example for the monochrome adapter, DEF SEG=&HB000: POKE 4000,1 should produce the happy face character at the beginning of the bottom line of an 80-character wide screen. DEF SEG=&HB800: POKE 4000,1 produces the same result for a color/graphics adapter. Replacing the 80 in the second OUT instruction with a 0 and retyping the two instructions will restore the screen. Replacing this 0 with a 1 and retyping the two instructions will cause the screen to scroll left one character.

The screen is able to scroll up because the registers inside the 6845 display controller chip are told to begin at the top left corner of the screen with the 81st character in the display buffer. For lines 80 characters in length, the 81st character is the first character of the second line. (Because the first character of a line is recognized as 0, character 81 is actually character 80.) The screen scrolls left because the registers

in the 6845 chip are told to begin with the second character in the buffer.

While the general instructions for prompting the screen to scroll are relatively simple, instructions for specific applications of this feature can become more involved. The problem is keeping track of where the next characters must go in the display buffer. For example, before the screen is instructed to scroll right, the first character on the bottom line is number 1,921 in the display buffer; after the scroll it becomes 2,001. Because of binary numbers, a display buffer for a 25-by-80-character screen holds 2,048 characters. The extra 48 at the end usually are not seen. After a scroll the new bottom row requires 80 characters in order to be filled. The extra 48 from the end of the buffer and the first 32 from the old first line of the buffer, which is no longer displayed on the screen, combine to supply these 80 characters. When scrolling up one more line (which requires replacing the number 80 in the OUT instruction with 160), the first character in the bottom row is taken from the 33rd character in the display buffer.

Trying to remember the correspondence between the screen and the buffer can be difficult and can unduly complicate programs. When working with a color/graphics adapter, the programmer

must also take into account the number of multiple pages. In addition, most applications do not function properly with this type of scrolling. For example, BASIC will not move its cursor to the new bottom line(s) of the screen after the scrolling mechanism has been used.

An alternative form of scrolling involves moving the characters within the display area so the upper left corner of the screen is always at the beginning of the buffer. All of the programs presented in this article use this method

and depend on MOVSW, the 8088 string move instruction, to move the data around within the display buffer.

LINE BY LINE, ROW BY ROW

The MOVSW command has two variations: MOVSB moves bytes, and MOVSW moves words from one memory area to another. The MOVSW instruction is significantly different from other 8088 instructions. It has no arguments, but requires that a number of 8088 registers be preset to indicate the amount of data

that are to be moved, as well as exactly where the data are to be moved from or moved to. The CX, DS, ES, SI, and DI registers and the DF bit of the flags register must be preset.

With these registers, a single MOVSW command with a REP prefix is all that is required to shift the screen one line or column in any of four directions (as determined by the contents of the registers). For proper emulation of scrolling, a blank line or column should be placed appropriately on the screen. A rectangular subset of the entire screen can be scrolled one line at a time with the help of a loop.

The first character on the second line is at offset 160, and its attribute is at offset 161. By slipping each character one word toward the beginning of the display buffer and blanking the last column, the screen is scrolled left. The character at the beginning of a line moves to the end of the line above. Prior to the blanking, the last column contains the contents of the original first column, which have been shifted up one position. The first character in the first row is overwritten and lost. If the characters are moved in the other direction, toward the end of the display buffer, the screen is scrolled right.

The DS,SI combination gives the 20-bit address of the first word to be transferred; the ES,DI pair gives the address of the first location that should receive a word. For a left scroll using the monochrome adapter, DS and ES must be set to &HB000, SI must be 2, DI must be 0, and CX must be 1,999 (this is the number of words moved). As each word is transferred by the REP MOVSW instruction, SI and DI are changed. If the DF bit of the flags register is 0, they are incremented by two; otherwise, they are decremented. The CLD and STD instructions are used to clear DF (to 0) and to set DF (to 1). To execute a left scroll, CLD must succeed in incrementing both SI and DI.

The CX register contains the number of bytes (for MOVSB) or words (for MOVSW) to be moved. The REP prefix refers to this register to determine the number of times that the MOVSW instruction has been executed. Note that words rather than bytes are moved in text mode because each character displayed has one byte that holds the character code and an accompanying attribute byte to be moved. A 25-by-80 screen holds a total of 2,000 characters. For horizontal scrolling, 25 rows of 79 characters must be moved, which calculates to 1,975 words. Vertical scrolling

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TABLE 1: Scrolling Parameters

		DS = ES	SI	DI	CX	DF
Monochrome	Up	&HB000	160	0	1,920	0
	Down	&HB000	3,838	3,998	1,920	1
	Left	&HB000	2	0	1,999	0
	Right	&HB000	3,996	3,998	1,999	1
C/6 text page 0 80 col	Up	&HB800	160	0	1,920	0
	Down	&HB800	3,838	3,998	1,920	1
	Left	&HB800	2	0	1,999	0
	Right	&HB800	3,996	3,998	1,999	1
C/6 text page 0 40 col	Up	&HB800	80	0	960	0
	Down	&HB800	1,918	1,998	960	1
	Left	&HB800	2	0	999	0
	Right	&HB800	1,996	1,998	999	1
C/6 medium resolution	Up ^a	&HB800	320(8,512)	0(8,192)	3,839	0
	Down ^a	&HB800	15,770 (7,678)	16,090 (7,996)	3,839	1
	Left	&HB800	2	0	8,095	0
	Right	&HB800	16,188	16,190	8,095	1
C/6 high resolution	Up ^a	&HB800	320 (8,512)	0 (8,192)	3,839	0
	Down ^a	&HB800	15,770 (7,678)	16,090 (7,998)	3,839	1
	Left ^b	&HB800	1	0	16,191	0
	Right ^b	&HB800	16,190	16,191	16,191	1

^aRequires two passes; values for second pass in parentheses.

^bUse MOVSB instruction.

Changing the register settings allows for manipulation in each of the display modes.

moves 24 lines of 80 characters for a total of 1,920 words. To simplify the program logic, the programs shown here move 1,999 characters.

For a scroll left, a REP MOVSW moves 2,000 characters forward across the screen and leaves blank the last column on the right. For a scroll right, the characters instead must be moved backward across the screen, beginning with the last character in the lower right corner, and the first column on the left must be left blank. (Columns can be blanked with a loop that fills the appropriate locations with spaces.) Table 1 gives a complete list of the register settings for each of the display modes.

Vertical scrolling requires moving rows of characters up or down with no horizontal shift. At first this may seem very different from horizontal scrolling; however, vertical scrolling uses a set of parameters only slightly different from those used for horizontal scrolling. These parameters are shown in table 1.

The SI register has a value of 160, which is the address distance between two vertically adjacent characters on adjoining lines. REP MOVSW moves each character up one line. When the bottom line is blanked, the operation is complete and the screen has been scrolled up one line. To scroll down, the param-

eters are changed to begin at the lower right corner, and the top line is blanked. The difference between the SI and DI register values remains 160.

SCROLLING IN GRAPHICS

Adapting these four programs for use with a color/graphics adapter requires little effort. The ES and DS registers must be changed to &HB800 so that they address page 0. Other pages can be accessed by changing this value again or by changing the SI,DI register pair. Changes to a few more values allow manipulation of a 40-column display (see table 1).

The scrolling programs, with the necessary adjustments for a 40-column display as well as for the color/graphics adapter, have been combined in listing 1, designed for use with the BASIC interpreter. The various scrolling routines are stored in the array DIR%, which has been doubly dimensioned to simplify the program. The four subroutines do not blank the new row or column, and the order of the assembly language instructions has been altered to simplify modification of the programs for varying column widths and adapters.

Line 510 tests for which adapter is in use; line 530 tests for the display mode; and line 550 tests for the column

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width. The code in lines 1000-1050 allows this program to be used interactively. These lines should be replaced with each user's own application code.

To scroll in graphics mode, the strategy remains the same, but some of the details change. For example, the MOVSW instruction may have to be replaced with MOVSB because, in graphics mode, the screen is addressed in scan lines rather than character lines. Eight scan lines are the equivalent of one character line, and 200 scan lines are the equivalent of one screen of 25 character lines. The scan lines are interleaved; the odd and even numbered lines are located in different areas of the display memory. Thus, in one of these areas, four scan lines belong to one character. Eight pixels (picture elements) belong to each character horizontally. In high-resolution mode, each pixel is determined by a single bit, and one byte makes one character. A line of 80 characters is 80 bytes in length. In medium-resolution mode, each pixel uses two bits, and two bytes make a character. Therefore, a line of 40 characters is 80 bytes long.

The values at which the registers must be set can be determined from these facts. To scroll up one character

line in either graphics mode, DS and ES are set to &HB800; DI, SI, CX, and DF are set as shown in table 1. The first half of the display buffer is scrolled by executing a REP MOVSW instruction. The second half is scrolled when DI is set to 8192 and SI is set to 8512. Scrolling down requires only that the values of SI, DI, and DF be changed.

The two graphics modes require slightly different set-ups for horizontal scrolling. However, horizontal scrolling is slightly easier because it requires only one pass through the display buffer. Graphics in medium resolution can be scrolled with MOVSW and the register settings shown in table 1. High-resolution graphics, on the other hand, because they have one character per byte, must use MOVSB for horizontal scrolls. The difference between DI and SI is 1 because each byte represents one line of a character. For the same reason, CX must be two times larger for high-resolution graphics than it was for graphics in medium resolution.

Scrolls up of a single raster line and scrolls left of only four pixels (half of a character's width) are possible in medium-resolution mode. The necessary changes can be worked out from the information provided here. How-

ever, the code to scroll the screen horizontally by an amount that is not equal to a multiple of eight bits is significantly more complex.

Listing 2, SCROLLASM, is a general scrolling routine. Its interface is designed for compiled BASIC. The program also works with the BASICA interpreter, but only after elaborate modifications. SCROLLASM must be assembled to SCROLL.COM; SCROLL.COM must be loaded with DEBUG then must be moved to high memory. In addition, BASICA must be loaded with DEBUG; it must be invoked with the DEBUG g command; and the high-memory copy of SCROLL.COM must be saved to SCROLL.BIN with BSAVE. SCROLL.BIN is suitable for BLOADing from BASICA.

SCROLL accepts one argument, the scroll parameter, which must be an integer and which is passed using BASIC conventions. This argument is positive for up/left scrolling and negative for down/right scrolling. Its magnitude ranges from 1 to 255 for vertical scrolling and from 257 to 511 for horizontal. (The numbers 1 to 255 indicate vertical scrolls by that number of lines. For numbers greater than 255, the number of columns scrolled horizontally can be found by subtracting 256.)

SCROLLASM begins by moving the single argument onto the stack and saving the values stored in the DS and ES registers. The current video state parameters can be obtained with a BIOS call. Next, the offsets of the upper left and lower right corners are computed. The strategy for the rest of the program is to set up registers for the actual scroll operation while placing the parameters needed for blanking the screen on the stack. The DI register will point to the upper left for up/left scrolls; it will point to the lower right for down/right scrolls. SI is first set to the opposite corner, but is then reset to the correct value for the data move just before the scroll takes place. BP contains the number of words to be moved in each row (for vertical scrolling this is the number of characters in a row), and BX is the number of rows (25 for horizontal scrolling). ES and DS are set to the base address of the display buffer, which is &HB000 for a monochrome adaptor and &HB800 for a color/graphics adaptor. Finally, DX is the difference between the source and destination addresses during the move.

As an example, suppose the program is scrolling up two rows on the monochrome adaptor. DS and ES are set to &HB000 to address the display

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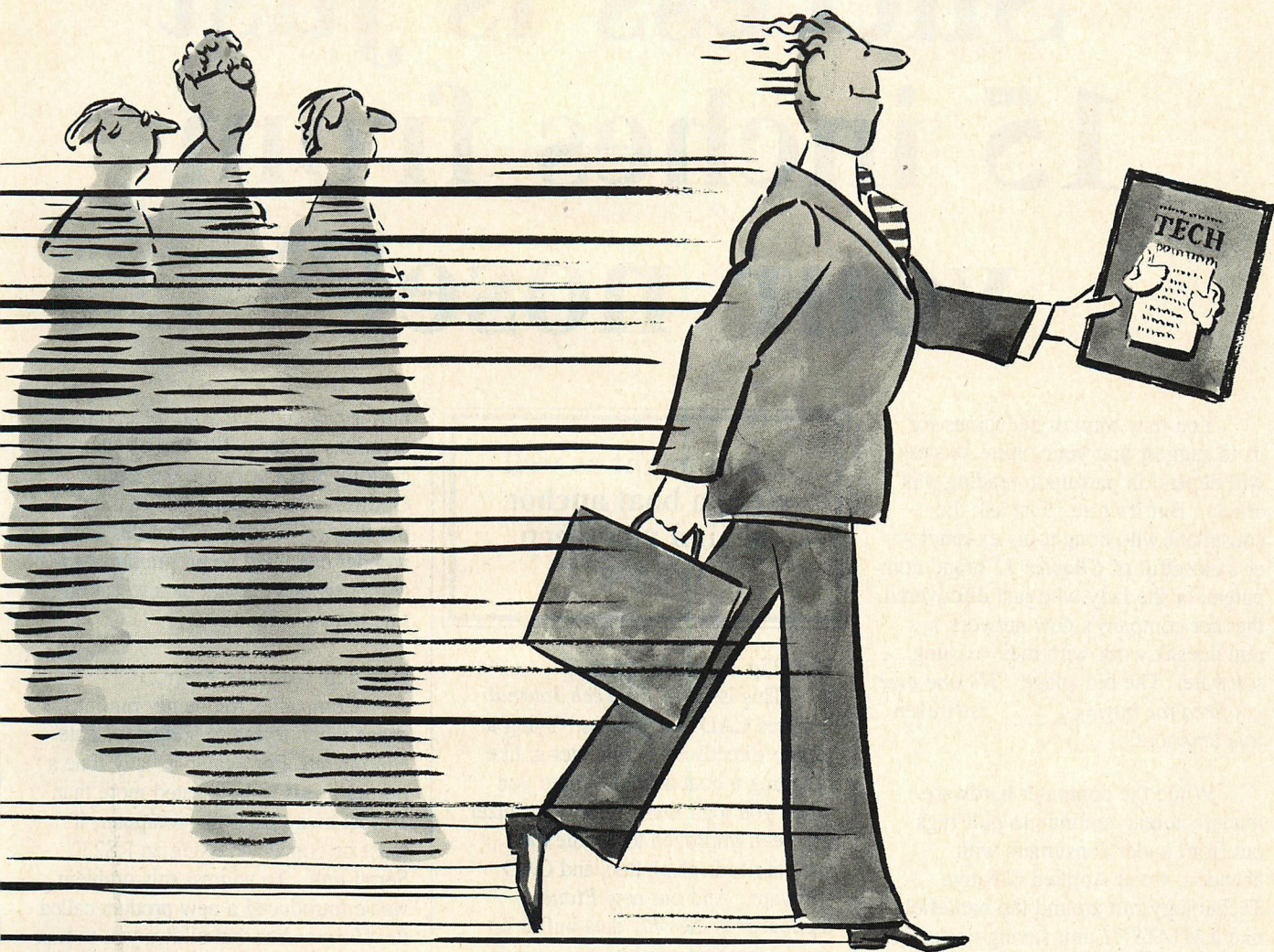
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buffer. DI is 0, which is the display buffer offset to the location receiving the first character moved, and SI (the lower right corner) is 3,998, the address of the last (the 2,000th) word on the screen. Each row must be moved in its entirety, so BP is 80, but only 23 rows are moved (BX=23). The first character in the third row moves to the position of the first character in the first row, a difference of two rows of 80 words or 320 bytes (DX=320).

The parameters necessary for the blanking of the bottom two rows are

placed on the stack during preparations for the scroll. Blanking begins at the bottom right hand corner of the screen, and the offset to this location is pushed onto the stack along with the number of rows to blank (2), the number of characters to blank in each row (80), and the row-to-row offset (160 bytes).

The loops for the final scrolling and blanking of lines are easy and fast after these elaborate preparations are complete. Special cases such as blanking or scrolling the entire screen could be handled with faster code, but,

because the difference in speed would not be perceptible to most users, this extra code is not really warranted.

With a few changes, this program can be made to scroll arbitrary rectangles within the screen, to replace the blanking operation with a fill of a given character and attribute, or to do wrap-around scrolling.



Harry E. Keller is the president of Paracomp, Inc., a software development firm located in Upton, Massachusetts. He received his Ph.D. in Chemistry from Columbia University.

LISTING 1: SCROLL.BAS

```
1 REM *** Four-way scrolling routines for BASIC interpreter ***
2 REM The four routines are stored in arrays for this example.
3 REM Defining new variables after the VARPTR calls will cause
4 REM errors because the location of the array will change.
5 REM Each routine scrolls one character and does not blank new
6 REM line/column.
10 DIM DIR%(11,3) ' For 2nd dimension: 0=UP, 1=DN, 2=LF, 3=RT
20 REM Move the subroutines into arrays
30 FOR J%=0 TO 3: FOR I%=0 TO 11: READ DIR%(I%,J%): NEXT I%,J%
40 REM Define function to change 80 to 40 columns
50 DEF FNCHG%(X%)=X%\2 AND -2
100 REM Scroll up subroutine
110 DATA &HBF1E,&H0000,&HBE06,&H00A0,&H00B8,&HBE0
120 DATA &HBED8,&HB9C0,&H0780,&HF3FC,&H07A5,&HCB1F
200 REM Scroll down subroutine
210 DATA &HBF1E,&H0F9E,&HBE06,&H0EFE,&H00B8,&HBE0
220 DATA &HBED8,&HB9C0,&H0780,&HF3FD,&H07A5,&HCB1F
```

```
300 REM Scroll left subroutine
310 DATA &HBF1E,&H0000,&HBE06,&H0002,&H00B8,&HBE0
320 DATA &HBED8,&HB9C0,&H07CF,&HF3FC,&H07A5,&HCB1F
400 REM Scroll right subroutine
410 DATA &HBF1E,&H0F9E,&HBE06,&H0F9C,&H00B8,&HBE0
420 DATA &HBED8,&HB9C0,&H07CF,&HF3FD,&H07A5,&HCB1F
500 REM Check which adaptor is in use? Change the
501 REM segment address in the subroutines if C/G adaptor
510 DEF SEG=&H40: IF (PEEK(16) AND 48)=48 GOTO 600 ELSE FOR I%=0
TO 3: DIR%(5,I%)=DIR%(5,I%)+8: NEXT I%
520 REM Text mode?
530 IF PEEK(73)>3 THEN PRINT "GRAPHIC MODE NOT ALLOWED": END
540 REM How many columns?
541 REM If 40 columns, then make changes in subroutines.
550 IF PEEK(74)=80 GOTO 600
560 FOR I%=0 TO 3: DIR%(1,I%)=FNCHG%(DIR%(1,I%))
570 IF I%<2 THEN DIR%(3,I%)=FNCHG%(DIR%(3,I%)) ELSE IF I%=3 THEN
DIR%(3,3)=1996
580 DIR%(8,I%)=DIR%(8,I%)\2: NEXT I%
```

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```

600 REM Set up the pointers to the subroutines
610 REM Must set these variables first so values don't change
620 USUB%=0:DSUB%=0:RSUB%=0:LSUB%=0:FAR%=0:WAYS=""
630 USUB%=VARPTR(DIR%(0,0))
640 DSUB%=VARPTR(DIR%(0,1))
650 LSUB%=VARPTR(DIR%(0,2))
660 RSUB%=VARPTR(DIR%(0,3))
1000 REM Now scroll in any direction
1010 INPUT "WHICH WAY (U,D,L,R): ",WAYS
1020 INPUT "HOW FAR: ",FAR%
1030 DEF SEG: FOR I%=1 TO FAR%
1040 IF WAYS="U" THEN CALL USUB% ELSE IF WAYS="D" THEN CALL DSUB%
ELSE IF WAYS="L" THEN CALL LSUB% ELSE IF WAYS="R" THEN CALL RSUB%
ELSE GOTO 1000
1050 NEXT I%

```

LISTING 2: SCROLL.ASM

COMMENT * SCROLLING ROUTINE

Scrolls the entire screen any number of lines or columns in any direction. Its single argument gives the direction and number of lines/cols.

CALL SCROLL(ARG)

If ARG is +, scrolling is up or left.
If ARG is -, scrolling is down or right.

The magnitude of the argument gives the number of lines and the rest of the direction information.

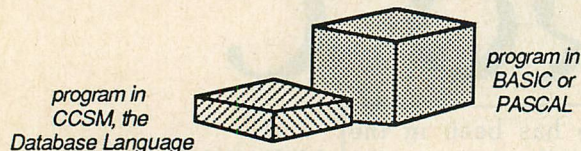
If |ARG| is between 1 and 25, direction is up or down.
If |ARG| is between 257 and 336, direction is left or right, and the number of columns is |ARG|-256. If rows or columns is greater than screen size or is zero, then the screen is entirely blanked.

```

*
;
; Little data segment here for temporary
; storage
;
DGROUP GROUP DATA
;
DATA SEGMENT PUBLIC 'DATA'
MODE_FLAG DB 0 ; Save mode flag returned from BIOS call
CRT_COLS DW 0 ; Save number of columns in display too.
DATA ENDS
;
CODE SEGMENT PUBLIC 'CODE'
PUBLIC SCROLL
SCROLL PROC FAR
ASSUME CS:CODE,DS:DGROUP
;
; Begin by picking up the argument from the
; calling routine and calling the BIOS for
; the current mode and screen size.
;
PUSH BP ; Save BP register
MOV BP,SP ; Point to stack to pick up the argument
MOV BX,6[BP] ; Get address of the argument
PUSH DS ; Save the data segment register
PUSH ES ; ES too in case using this with interpreter
PUSH [BX] ; Save the argument for later
MOV AH,15 ; Code for "return current video state"
INT 10H ; Call BIOS
; Returns: MODE in AL, COLS in AH, PAGE in BH
MOV MODE_FLAG,AL
; Save mode code for later
MOV AL,AH ; Get COLS to AL
CBW ; Make it a word
MOV CRT_COLS,AX
; and save it
;
; Multiply the screen width by the screen

```

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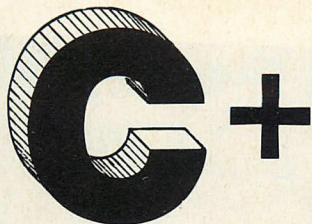
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close
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cmpstr
conbuf
conc
cos
cpyst
creat
curblk
curslin
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curson
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fgeto
filetrap
find
floor
fopen
fprintf
fputs
fread
free
freopen
fscanf
fseek
fiell
fwrite
getc
getch
getch
getchar
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getdseg
getd
putd
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alloc
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movmem
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outp
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poke
poscurs
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printf
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putchar
puts
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realloc
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PROGRAMMING PRACTICES

```
; length to get area into AX. Multiply by the
; page number to get upper left offset from
; the beginning of the display buffer. Add
; to this the difference between the upper
; left and lower right addresses to get the
; offset from the beginning of the
; buffer to the lower right corner of the
; current page being displayed.
;
```

```
MOV CX,50 ; Assuming 25 rows always and 2 bytes/char
MUL CL ; Get size of screen
MOV SI,AX ; SI will have offset to lower right corner
DEC SI
DEC SI
MOV CL,BH ; Figure page offset
MUL CX ; from display buffer base
MOV DI,AX ; Now have upper left offset in DI
ADD SI,DI ; and lower right in SI
;
```

```
; Check argument to see if scroll or blank
; operation is requested. If blank, then do
; it right away.
;
```

```
POP DX ; Get the argument saved on the stack above
BLANKSCREEN:
```

```
CLD ; Assume forward direction for now
MOV AX,DX ; Keep a copy of the argument in AX
TEST DX,DX ; Which way to scroll?
JNZ REALSCROLL
```

```
; If non-zero, then it is a real scroll
```

```
; This is a blank screen operation, not a
; scroll. Blank entire screen by specifying
; no rows or cols for scroll and all rows and
; cols for blank operation.
;
```

```
PUSH CRT_COLS ; Blank all columns
MOV AX,25 ; and
PUSH AX ; all rows
XOR BX,BX ; Scroll no rows
XOR BP,BP ; and no columns
JMP COMMON ; Proceed to common scrolling code
```

```
;
; A real scroll has been requested. Check
; the sign of the argument to determine which
; corners the DI and SI registers should
; point to. If the registers must be
; reversed, then perform STD to reverse
; direction.
;
```

```
REALSCROLL:
```

```
JG FORWARD ; If >0 then DI, SI, DF, and DX are ok
XCHG DI,SI ; else assume lower right corner destination.
STD ; Need to set direction flag too.
NEG DX ; Get the absolute value of the argument.
```

```
FORWARD:
```

```
MOV BP,CRT_COLS ; Get the number of columns into BP.
MOV CX,DX ; Put argument into CX for next check.
SUB CX,256 ; Is the scroll vertical or horizontal?
JG HORIZONTAL ; Horizontal if > 256.
```

```
; ***** VERTICAL SCROLL CODE *****
```

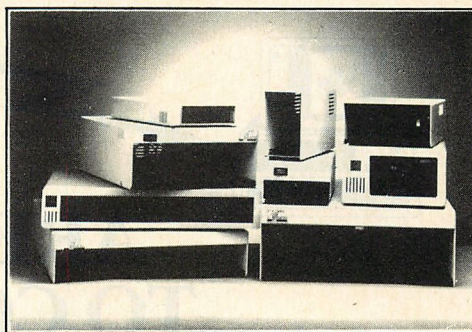
```
; Check that # rows is ok. Save parameters
; on stack for the blank operation after
; scroll. Calculate the distance in bytes to
; move the data (including the sign from the
; argument), and put result in DX. Continue
; with common scroll code section.
;
```

```
MOV BX,25 ; Total number of rows on the screen
SUB BX,DX ; less number moved = number to move.
JLE SETBLANK ; Asked for whole screen or more.
```

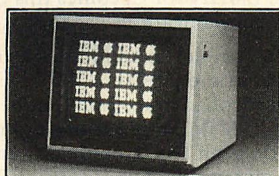
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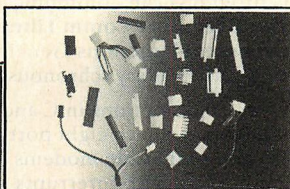
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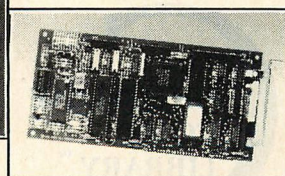
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```

PUSH BP      ; Save chars/row for blanking rows later.
PUSH DX      ; Save number of rows for blanking too.
MOV CX,160   ; There are 160 bytes per row
IMUL CX      ; Get offset for MOVSW
MOV DX,AX    ; Source-Destination offset into DX
JMP COMMON   ; Proceed to common scrolling code

```

```

; Set up the registers to do a blank screen
; operation. DX must be zero and SI and DI
; must be swapped back if already swapped.

```

SETBLANK:

```

XOR DX,DX    ; Set argument to zero.
TEST AX,AX   ; Was this a down/right operation?
JGE BLANKSCREEN

```

```

; No, go directly to blank screen.
XCHG SI,DI   ; Yes, reset SI and DI before
JMP BLANKSCREEN

```

```

; proceeding to blank entire screen

```

```

; ***** HORIZONTAL SCROLL CODE *****

```

```

; Figure number of columns to move characters
; by. If too large, then it's a blanking
; operation. Set registers for common code
; and scroll operation.

```

HORIZONTAL:

```

SUB BP,CX    ; Total cols less num cols moved = # to
; move
JLE SETBLANK ; Too many cols means blank screen
PUSH CX      ; Save number of columns to blank
MOV DX,CX    ; Pick up words/row offset
TEST AX,AX   ; Check sign of parameter
JG PLUS      ; OK
NEG DX       ; Get back correct sign

```

PLUS:

```

SHL DX,1     ; Change words to bytes

```

```

MOV BX,25    ; Number of rows to visit
PUSH BX      ; Save rows to blank
;
; ***** COMMON CODE *****
;
; Complete the set up for the scroll by
; calculating the row offset (bytes per row)
; and setting up DS and ES to point to the
; display buffer.

```

COMMON:

```

MOV CX,CRT_COLS
; Calculate row offset: get # cols on
; screen.

```

```

SHL CX,1     ; Convert from words to bytes.
TEST AX,AX   ; Get the sign right
JGE ARGPLUS  ; by forcing it
NEG CX       ; to be the same as AX.

```

ARGPLUS:

```

PUSH CX      ; Save row offset for blank operation.
MOV AX,0B000H ; Get base segment address for mono display.
CMP MODE_FLAG,7
; Is this the monochrome adaptor?
JE MONO      ; Yes, leave base address alone.
MOV AX,0B800H ; No, set up for color/graphics adaptor.

```

MONO:

```

MOV DS,AX    ; Use AX to set up DS
MOV ES,AX    ; and ES.

```

```

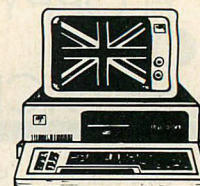
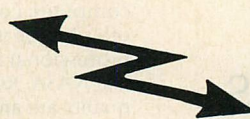
; Now, DI points to correct corner of screen
; SI points at the opposite corner
; The DF bit is set properly
; BP = words per row to move
; BX = number of rows to do
; DX = destination-source offset
; DS and ES are set to the correct segment

```

```

ASSUME DS:NOTHING

```



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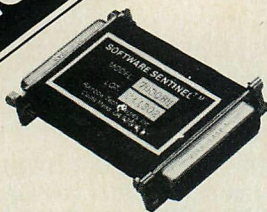
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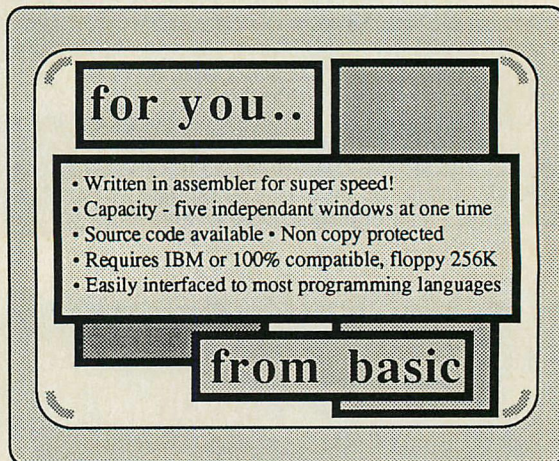
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```

; Perform the actual scroll here. Get the
; saved row-to-row distance into
; AX, save the opposite corner value, and set
; SI correctly for the MOVSW. The actual move
; uses a loop on BX to go from row to row and
; the REP MOVSW instruction to do each row.
; SI and DI must be saved before doing
; the MOVSW because they are changed by it.
; Adding AX to the SI and DI sets
; them up for the next row.
;
POP     AX           ; Get row to row offset.
PUSH    AX           ; Save for blanking.
PUSH    SI           ; Save opposite corner for blanking.
MOV     SI,DI        ; Ready to adjust source by DX.
ADD     SI,DX        ; Adjust source.
SCROLL:
MOV     CX,BP        ; Words per row.
PUSH    SI
PUSH    DI
REP     MOVSW        ; Move the words.
POP     DI
POP     SI
ADD     SI,AX        ; Point to the
ADD     DI,AX        ; next row.
DEC     BX           ; Count down.
JG      SCROLL       ; Loop until all rows are done.
;
; Now must blank rows or columns. The
; information needed has been saved on the
; stack. Retrieve it. Put the blank
; character and attribute in AX in
; preparation for the REP STOSW instruction,
; and set the direction correctly. The blank
; operation is performed one row at a time
; with the REP STOSW instruction. The rows
; are done with a loop on BX.
;

```

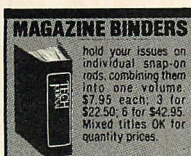
```

POP     DI           ; Get correct corner of the screen.
POP     DX           ; Get the row offset
POP     BX           ; and the row count
POP     BP           ; and the character count.
MOV     AX,720H      ; 720H is a blank with normal attributes.
CLD                     ; Assume forward direction for STOSW.
TEST    DX,DX        ; Is it?
JL      BLANKLOOP    ; Yes, go ahead.
STD     BLANKLOOP     ; No, change direction bit.
BLANKLOOP:
MOV     CX,BP        ; Pick up the character count.
PUSH    DI           ; Save DI.
REP     STOSW        ; Store the blanks in display buffer.
POP     DI           ; Get DI back.
SUB     DI,DX        ; Move to the next row.
DEC     BX           ; Decrement the row count
JG      BLANKLOOP    ; and keep going until all done.
;
; Scrolling and blanking is complete.
; Restore saved registers and return.
;
POP     ES           ; Restore ES register.
POP     DS           ; Restore DS register.
POP     BP           ; Restore BP register.
RET                     ; Return to caller.
SCROLL ENDP
CODE   ENDS
END

```

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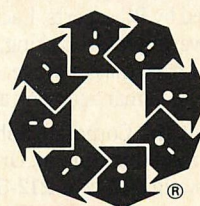
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Federal Encouragement

A recently released CBO report summarizes the benefits available to high-tech companies for research and development.

As most taxpayers know, the federal government is the largest consumer in the United States. The government realizes this also and considers the policy implications of its economic power. For example, the Congressional Budget Office (CBO) has issued a report entitled "Federal Financial Support for High Technology Industries," analyzing the need for, and adequacy of, such support. The report is meant to guide tax and fiscal planners. It is anyone's guess whether (and when) the options discussed in the report will be implemented. Nonetheless, it is of value in summarizing the benefits available to high-technology companies.

The CBO report was motivated by the concern that

U.S. technological primacy is being challenged internationally as never before. There is a perception that much of this competition is subsidized by foreign governments, while the U.S. government gives relatively little assistance to high-technology industries.

High-technology industries are of interest to policy makers because

it is generally recognized that research benefits the nation more than it benefits any individual company, and that private firms tend to devote less (sic) resources to research and development than the public interest would warrant; this is particularly true for high-technology industries, which perform roughly half of all commercial R&D in the United States.

High-tech companies are defined by the report as "research-intensive industries growing more rapidly in employment than the all-industry average." The report defines a company as *research-intensive* if its ratio of R&D to sales is one-third higher than the average for manufacturing companies, and as *growing rapidly* if its 10-year increase in employment is above the average for manufacturing companies. Computers, communications equip-

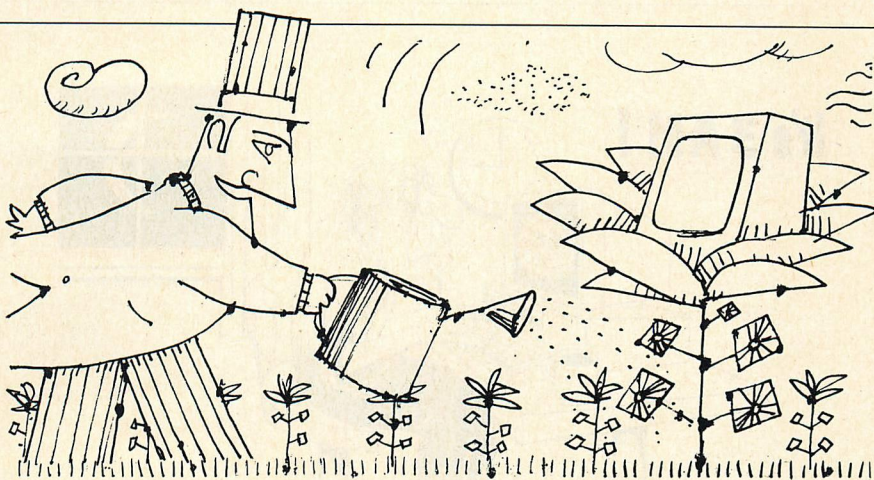


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ment, and electronic components all fit within those definitions.

Such companies are of economic importance because they create what the CBO calls *free knowledge*. According to the CBO, "Technological followers often are able to retrace at low cost the thoughts of innovators, and to learn from them." The transmission of free knowledge occurs "through analysis of the products themselves; through formal channels, such as journals; and through informal channels, such as... lunches," and through the creation of expertise in individuals who carry it to other employers. The CBO report quantifies the value of high-tech industries to the nation's economic well-being, noting that in 1982, these industries produced a \$30-billion trade surplus and half of all private manufacturing R&D.

Having concluded that high-tech industries deserve encouragement, CBO analyzes what federal encouragement is currently available.

Federal support for an industry can take several forms: direct spending, tax benefits (often referred to as *tax expenditures* because a taxpayer's *benefits* are the Treasury's *liabilities*), favorable regulatory environment, protection from foreign competition (tariffs) or from domestic competition (govern-

ment-sanctioned monopolies as the telephone company used to be).

In the area of direct spending, the Department of Defense leads the list with its Independent R&D program (which reimburses federal contractors for research projects with potential federal agency use, at an annual cost of \$1.6 billion), its Bid and Proposal program (\$900 million/year), its Very High Speed Integrated Circuit (VHSIC) program (\$50 million/year), and its Manufacturing Technology program (annual cost: \$100 million/year). The National Aeronautics and Space Administration has a smaller scale Independent R&D program (\$75 million/year) and Bid and Proposal program (\$50 million/year) in addition to its sponsored research (\$500 million/year). The National Bureau of Standards spends \$100 million a year on research and development of measuring standards, and the National Science Foundation spends nearly \$1 billion a year on R&D.

The government points with pride to the most visible results of these efforts: production-model integrated circuits and nonstick frying pans. It anticipates commercially valuable results from work done in the VHSIC program, from development of CMOS technology and from a more ambiguous catalyst

role of the program in encouraging independent R&D by the participants (IBM, Texas Instruments, Motorola, and National Semiconductor among them).

The most difficult federal support to quantify (and the more generally useful support, especially to companies not yet in the league of the VHSIC participants) is the tax expenditure category. The CBO report notes three tax mechanisms to support R&D: the Internal Revenue Code Section 174 provision for the deduction (rather than amortiza-

tion) of qualified research and experimentation expenses, the 25-percent tax credit for increases in qualified expenses over the previous three years' average, and R&D limited partnerships.

Section 174 permits taxpayers to deduct, in the year incurred, the costs of certain research activities. However, many of those costs must be amortized over several years (that is, the taxpayer can deduct only a fraction of the total cost in each year). The result is what the CBO characterizes as "the equiva-

lent of an interest-free loan to the taxpayer of his or her deferred tax liability." For example, a taxpayer in the 25-percent bracket saves \$250 with a \$1,000 deduction. If the \$1,000 must be amortized over five years, the taxpayer saves \$50 per year for five years. Converting an amortizable item to a deductible item is equivalent to lending the taxpayer \$200, repayable in four annual installments without interest. The CBO estimates that Section 174 results in \$3.7 billion of interest-free loans of this type annually.

In brief, the tax credit for increasing R&D allows high-tech companies to reduce their taxes by an amount equal to 25 percent of the excess of R&D expenses over the average of such expenses for the preceding three years (see "R&D Tax Incentives," Max Stul Oppenheimer, May 1985, p. 223 for a more complete discussion). The CBO points out several flaws with the credit system. The most basic problem is that the credit benefits taxpayers only to the extent that they would otherwise have tax liabilities. As the report states, "much evidence" shows that new high-tech firms are among the most innovative, yet are not sufficiently profitable to take advantage of the available credit.

A second flaw in the credit system is that it encourages bunching R&D expenditures rather than steadily increasing expenditures. This is because the credit *base* increases when expenditures increase. Thus, a taxpayer who increases expenditures by \$1 in year one receives a 25-cent credit, but in years two through four the base will be 33 cents higher than if the first-year expenditures had not been made; any credits in years two through four will be reduced by 25 percent of 33 cents. Thus, the 25-cent credit reduces future credits by 25 cents; taxes are postponed, not reduced, if the taxpayer increases R&D expenditures steadily.

The final tax incentive for R&D is the R&D Limited Partnership (RDLP), a variation on the standard tax-shelter theme of setting up a partnership consisting of a general partner who runs the business and over-taxed limited partners who have no control of the business, a less than proportionate participation in the profits of the business, and a more than proportionate share of the tax benefits generated by the business. (In the case of an RDLP, the tax benefit consists primarily of the Section 174 expensing of R&D costs because the credit for increased R&D is not available to RDLPs). The report de-

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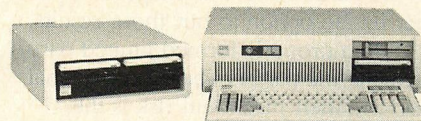
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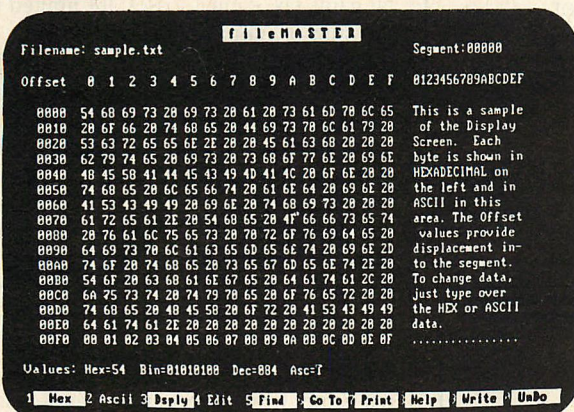
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scribes an RDLP as consisting of a group of limited partners who provide the bulk of the capital to perform R&D desired by the general partner. The partnership then hires the general partner to perform the research and development. The results of the R&D belong to the partnership, but the general partner has an option to buy those results.

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ships are not taxable, the tax benefits flow through to the partners in accordance with their agreement. Typically, the limited partners get 99 percent of the benefits. Thus, their investment is reduced by the amount of the tax benefits they receive. If the project is unsuccessful, the loss is softened by the tax benefits. If the project is successful, the gain is recognized as a long-term capital gain and therefore taxed at a 20-percent rate rather than at the 50-percent income rate.

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If the technical requirements are satisfied, great latitude is allowed in the structuring of RDLPs. The tax benefits of such an arrangement ordinarily dwarf the costs of setting up and maintaining an RDLP, yet the CBO report estimates that of the \$44 billion spent on R&D, only \$1 billion is spent through RDLPs.

The report notes some aspects in which the tax system works against high-tech industries. The most significant of these is the depreciation system. Some argue that because of the rapid pace of technological development, high-tech capital equipment becomes obsolete far more quickly than standard depreciation practices allow it to be written off for tax purposes.

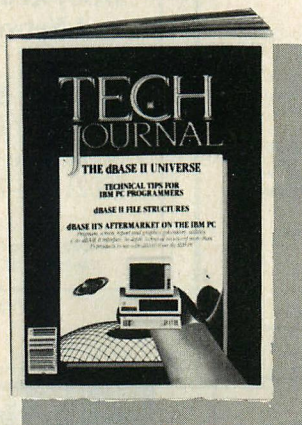
A second disincentive to high-tech investment is the asymmetry of the capital gains tax: capital losses are limited to the sum of capital gains from other transactions plus \$3,000. Thus, the Treasury may not share in the full loss on a high-tech capital investment, but it does participate in full in case of a gain. This is true of any capital investment and is not specifically applicable to high-tech ventures unless the assumption is made that these are more likely to produce losses than are other ventures. A survey cited in the report indicates that more than half of all investments by venture capital firms remain at or below original value, while one in ten increases in value by five times or more.

To the extent that federal payments or tax benefits reduce a company's costs, the company's chances of being that one in ten increase. The CBO report is a good road map of existing benefits. As long as its limited supply lasts, CBO will send a free copy of the report on request.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard, located in Baltimore, Maryland.

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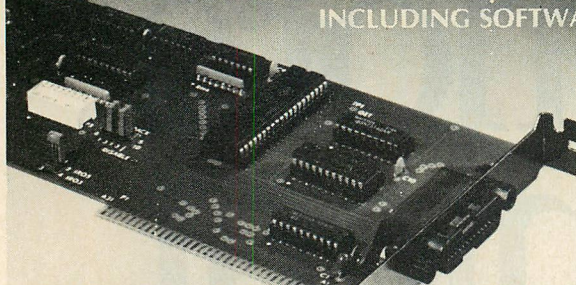
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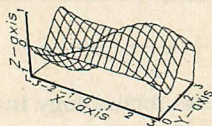
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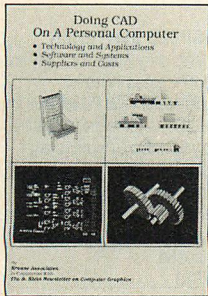
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Help With CAD/CAM

These two books fall short of a complete coverage of this field, but offer worthwhile introductory material.

Doing CAD on a Personal Computer

Krouse Associates in conjunction with The S. Klein Newsletter on Computer Graphics (Technology & Business Communications, Inc., Sudbury, MA 1985) 121 pages, paper, \$179 in the United States, \$191 elsewhere



Krouse Associates' *Doing CAD on a Personal Computer* is intended for designers and engineers considering using their PCs for computer-aided design applications. Priced at

\$179 it is a rather expensive investment; however, it provides a quick and practical introduction to CAD.

The book begins with an overview of the history of CAD, then continues with chapters that discuss the "Big Benefits" as well as the possible "PC Pitfalls" of computer design. Other chapters examine system hardware, applications software, and networking. Advice is given on buying a system and on the major vendors of these systems, including the programs they offer. The reader must keep in mind that much of the material discussed is already a year old and must be reconciled with new developments in the PC marketplace.

This book is intended as an overview; each subject is treated only generally. The quick sketches help the reader identify viable applications of CAD, but more information would be necessary in order to make a specific decision on a CAD system.

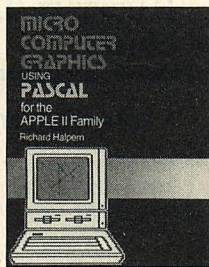
The book is spiral bound; the pages are double spaced and printed on only one side, providing the user with ample space for annotations throughout the text. The appendixes list principle vendors in a helpful but dated

telephone and product cross-reference list, and the glossary provides moderate aid in reading technical literature. The book lacks illustrations of hardware elements, but includes a collection of photos of CAD outputs and systems.

Doing CAD on a Personal Computer clearly leaves room for improvement. It can, however, help define the reader's focus on the subject and provide a good starting reference from which to make intelligent choices about the most appropriate CAD tools.

—RICHARD G. ANGELL

Microcomputer Graphics Using Pascal for the IBM PC and Compatibles Including Turbo Pascal Richard Halpern (Harper & Row, Publishers, New York, NY 1985) 238 pages, paper, \$19.95



Pascal programmers looking for an introduction to the concepts of the rapidly developing field of computer-generated graphics will find Richard Halpern's book a good investment. It is a well-organized textbook that covers a wide range of graphics concepts, including simple lines and bar charts as well as three-dimensional wire graphics.

Each chapter begins with an outline of objectives then proceeds to a general discussion of the graphics concept to be considered. Example Pascal programs illustrate possible applications of the concepts.

Each chapter presents a set of problems for the reader to solve; the answers are not provided. Reference lists are given at the end of every chapter; these include many of the standard reference books and articles that are pertinent to the material discussed.

The first chapter discusses graphics hardware, including displays, plotters, and digitizers. UCSD's Turtlegraphics commands, which correspond closely with the Turtlegraphics commands of Turbo Pascal 3.0, are used as graphics primitives throughout.

Other topics examined include lines and polygons and methods for handling coordinate systems; two-dimensional transformations, including translation, scaling, and rotation; graphics data structures and how they can be written to and read from disk; window and viewport mapping, clipping, zooming, and panning; and the concepts involved with three-dimensional graphics coordinate systems, such as projection, viewing angle, transformations, and hidden line removal.

Halpern does not teach his readers Pascal. He assumes they understand the UCSD filing system and Pascal control and data structures. He does present a brief discussion of record types, UCSD file access, and linked lists. Readers unfamiliar with these concepts should learn enough from this short mention to understand the examples, but may have trouble modifying these routines or designing their own.

Readers must be comfortable with trigonometric and matrix operations to understand the more advanced graphics concepts, such as transformation and hidden line removal. An appendix briefly reviews the mathematical principles used in the book.

The title of this book is misleading. The graphics concepts presented are not directed specifically toward use with IBM PCs or compatibles. The title's reference to Turbo Pascal seems an afterthought; the only mentions of this language are made in the Preface and Appendix C, providing a brief overview of Turbo Pascal 2.0's graphics commands and file capabilities.

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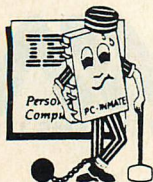
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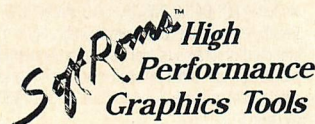
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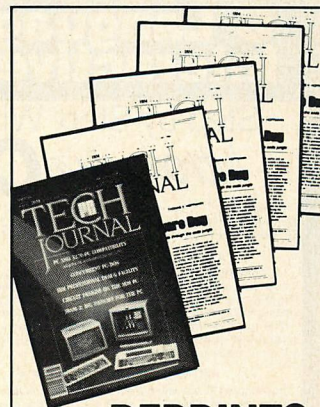
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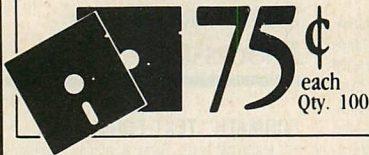
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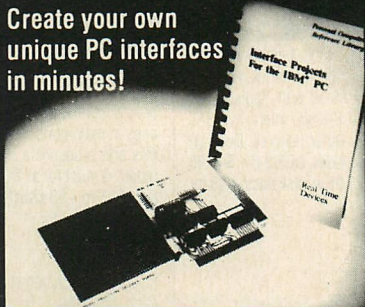
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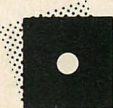
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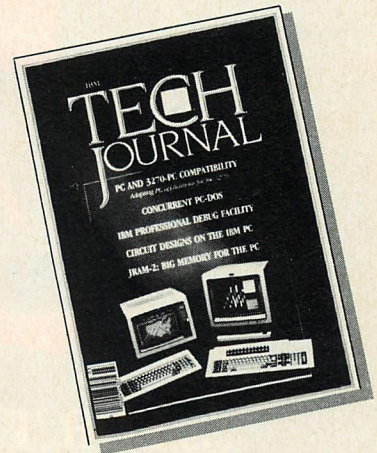
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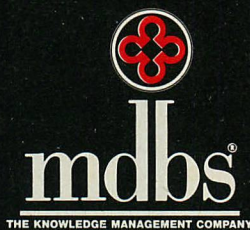
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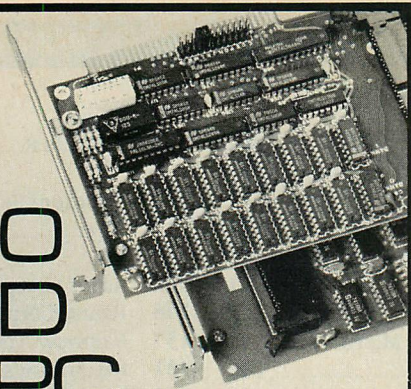
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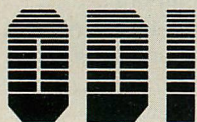
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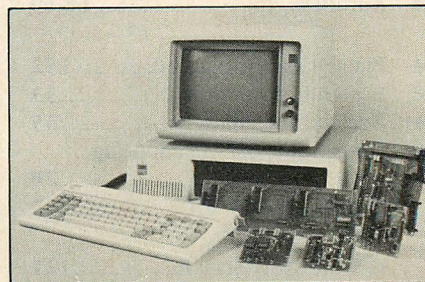
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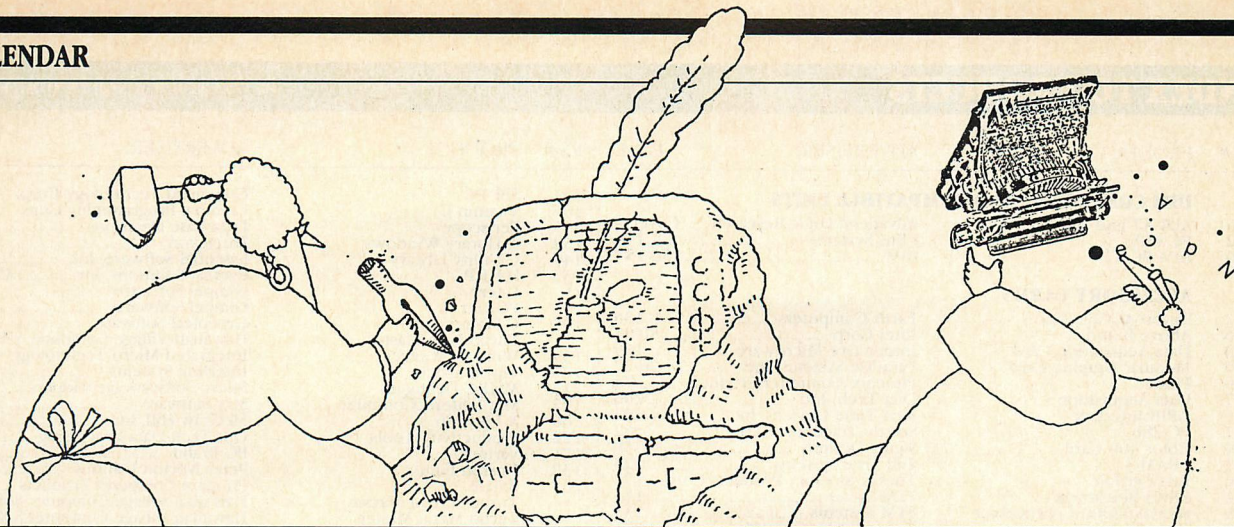
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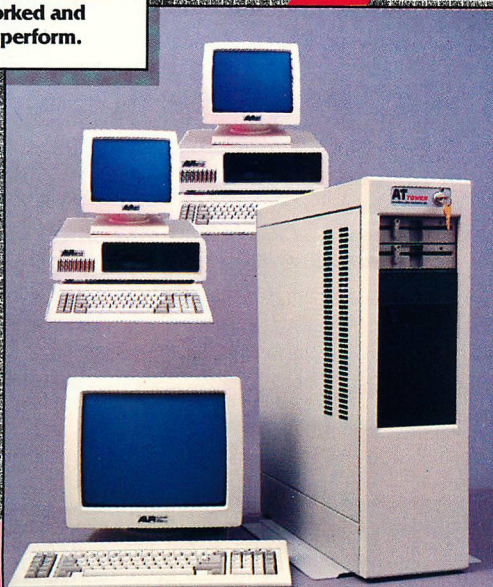
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